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A SYMPOSIUM ON SCIENTIFIC MANAGEMENT AND EFFICIENCY IN COLLEGE ADMINISTRATION

COMPRISING AMONG OTHERS
THE PAPERS PRESENTED AT THE EFFICIENCY SESSION
OF THE TWENTIETH ANNUAL CONVENTION OF THE
SOCIETY FOR THE PROMOTION OF ENGINEERING
EDUCATION, HELD AT BOSTON, MASS.,
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INTRODUCTION.*

BY FRANK B. GILBRETH,
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The purposes of the papers of this session are to show:

1. What scientific management is.
2. What it can do.
3. Its possible bearing upon, and application to, academic efficiency.

Scientific management is measured, functionalized management,—management that has submitted to measurement, and that has, through the results of this measurement, so divided and arranged its work as to demand and utilize individuality in its workers.

We may well represent such management by the following functional chart.

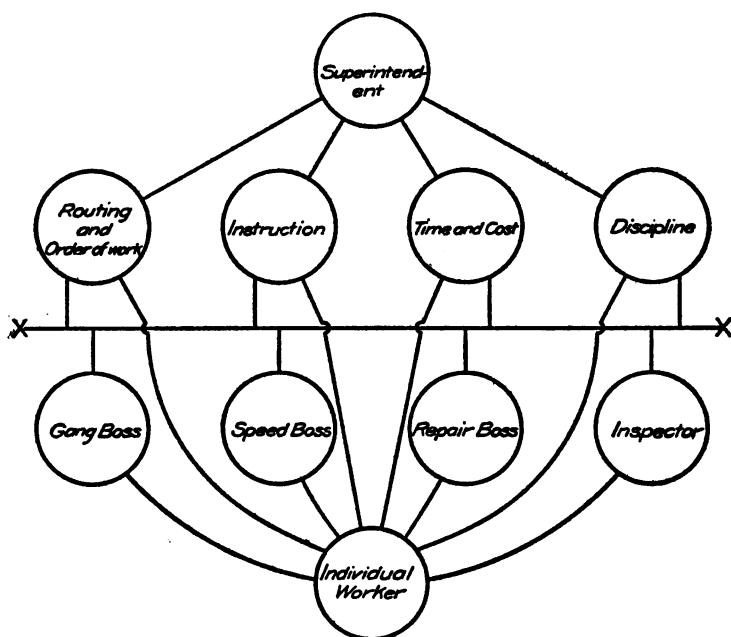
“X-x” represents the division between the planning and the performing. The five circles above the line “x” represent the superintendent and the four functions of the planning department,—the five circles below the line “x,” the four functions of the performing department and the individual worker. The lines connecting the various circles represent the lines of authority, if read downward; the paths from which direction and teaching come, if read upward.

This chart not only shows the method of operation of scientific management, but also indicates the universality of its field of application.

It is this universality that the various speakers and writers at this session will show. They are all men of action, whom I have persuaded to leave their work for today to tell you of their interpretations and applications of the principles of

* Introductory remarks by Chairman Gilbreth at the session of the Boston Convention of the S. P. E. E. devoted to scientific management.

scientific management as laid down by its founder, Dr. Frederick W. Taylor. Men of widely varying training and experience, they are all versed in the practice as well as the theory of scientific management, and all believe that through scientific management alone can the problems of the academic as well as the industrial world be attacked and solved. It is to this belief that they have come here to testify today, and they will bring to you such justification for their belief that we know you too must believe.



With measurement has come the day of science. With scientific management, the result of measurement, has come the application of the laws of science to all work,—yours and ours. This is the message that we bring to you today,—and it is to this message that I know you desire to listen.

We all,—President Raymond, Dean Anthony, Professor Norris and myself, have coöperated to make it possible that

this message be brought to you. It has back of it a unity of purpose and will. We ask, now, your coöperation in carrying it to all the great schools and colleges that you represent. Through your coöperation only can it be made possible that scientific management shall come into its own as the great bridge connecting and unifying the academic and the industrial worlds.

EDUCATIONAL DEMANDS OF MODERN PROGRESS.

BY HARRINGTON EMERSON,

President of The Emerson Company, New York City.

Erie is a fairly peaceful lake, quite navigable by sailors of ordinary prudence and skill.

Ontario, further down stream, is another peaceful lake, also quite navigable by sailors of ordinary prudence and skill.

Between the two lakes courses the Niagara River. No amount of skill, no prudential methods insuring success on Lake Erie are of any use in the rapids above and below the falls, especially of no use in the thousand feet of swirl which include the cataract. If the boatman can make the portage from the upper to the lower lake, he may again use his old skill.

But Lake Ontario narrows into the St. Lawrence and in time this river broadens out into the Atlantic. Even the skill of the French Canadian pilot through the rapids of the St. Lawrence would not avail, would not fit him to navigate either sailer or steamer across the great oceans. The qualities of courage, resourcefulness, calmness will count, but not previously-acquired specific knowledge of streams and shores.

Time is also a river. It also has its lakes, its rapids and its issuance into a limitless ocean.

We, voyagers down the river, are now already in the stormy channel between two epochs. As never before in the history of the world has past knowledge, past experience, past skill, counted for so little, and never before in the history of the world have men been so poorly prepared for what was ahead of them.

Go back in Europe, one, five, ten, fifteen centuries, and it is routine that counted. The lives of 95 per cent. of men and women were fixed by status. The men died of old age near

where they were born, working at their fathers' and grand-fathers' trade. As with Chinese women, it was absolutely necessary to begin mental, physical, moral foot-bindery at the earliest possible age. The Arabs are living to-day as they lived in the time of Abraham. Neither their language, nor their customs, nor their clothes, nor their food has changed. Forty years ago in Germany, in Italy, in Greece little girls were taught to knit and spin and were kept at it every possible minute from dawn until dusk, until death came to them as old women. Routine training was all important because routine work constituted nearly all of the world's work.

But routine training has not fitted the boatman on the waters of life to cope with the rapids between one epoch and another, has particularly not fitted the boatman who has floated down a narrow river confined by the banks of routine to navigate a limitless ocean.

At El Tovar, on the brink of the Grand Cañon of the Colorado, is a battered boat. It belonged to two inexperienced men who, in it, came down the full length of the river. Although the Colorado is one of the most difficult and dangerous rivers in the world, even danger can belong to routine. Each rapid is largely a repetition of the others. These men acted with typical routine inspiration. They floated their boat down stern foremost, rowing against the current, pointing at what was behind and not at what was ahead.

This simile likening time to a river, likening disturbing epochs to cataracts, likening the future to the limitless ocean, may be picturesque, but I shall justify it.

When previous experience of an industrial kind is not available, then we must use contemporary experience of a similar kind.

Races of plants, of insects, of animals, have met crises for which previous experience was not available. Those who made the most mistakes perished; those who made the fewest, survived. The survivors can give us suggestions.

The aphides, plant insects, are normally without wings. One generation succeeds another with monotonous regularity.

There is nothing to do but stick fast to the particular plant until its leaves have been devoured or are withered. When famine occurs what do the aphides do? The next generation has wings and flies away. Those who fail to grow wings perish.

Bees similarly work day after day with all the discipline and habit of routine. It looks as if no change could ever come. Suddenly routine is wholly forgotten. A swarm gathers, abandons the hive, the accumulated stores, the location, everything that made bee life worth while, and, hanging to some tree, waits while scouts seek some new refuge, the hollow of a tree, a crevice in the rocks. The race of bees is preserved in these crises, not by routine, but by desperate and to man inconceivable initiative.

Among the migratory birds we find the same hints. The stork is the emblem of domesticity. On the roof tree it occupies the same nest year after year; it is counted on to bring babies to human homes, but when winter comes it forgets domestic routine and departs. A stork marked in Norway was captured a few weeks later in South Africa.

Hatched in the cool waters of a mountain stream, salmon, when partly grown, swim down and out into the salt sea. Where they stay for three years no one knows. They break away from the routine of the river and go out into a new life for which no previous experience has prepared them. At the end of four years, giving up the routine of the sea, they return to ascend rivers, to leap up waterfalls, to lead a life which is wholly and absolutely new.

In man, infancy and youth are marked by crises by which a comparatively long period of routine is broken by great and revolutionary initiative. There are sudden and tremendous changes, from ovum to embryo, from foetus to breathing life, from birth to weaning, from childhood to puberty.

Whether insects, fish, birds or men, when the crises come, only those who develop initiative, who forget routine, who look ahead and not backwards, survive. We therefore find that initiative alternates with routine as part of the law of progress.

But are we now in a period of transition, a peculiar epoch, an age requiring for survival initiative and not routine? If we are in such an epoch, then it is immensely important to free ourselves from the trammels of routine and to grow the wings of initiative. Those who do not will perish.

Let me demonstrate to you by a single example that we are in this epoch of transition. To bring out the difference between the old order and the new, I shall compare the generation of power in China and in America. Make no mistake! The difference is not one of race capacity. The yellow race is as numerous as the white, it has counted among its members great religious teachers, the greatest of conquerors, the greatest of artists, it has evolved a civilization that has endured two thousand years. We fear the Chinese as we do not fear negroes, Indians or Mexicans. We fear them on account of their superlative qualities. The difference at the present time between the white and yellow is not one of race capacity but solely of opportunity.

In China men are paid \$0.01 an hour for climbing tread-mills actuating stern wheels which propel river boats. These coolies convert their stored human muscular energy into mechanical foot-pounds. From experience with treadmills in British prisons we know exactly the mechanical equivalent of hard labor. It is a climb of 8,640 feet each 24 hours. This is the limit of human endurance for a succession of days. To convert this into horse-power we must know the man's weight and the number of hours he works each day. The average weight of man is about 150 pounds. A man of this weight climbing 8,640 feet in 24 hours yields 1,296,000 foot-pounds. A horse-power for 24 hours is 47,520,000 foot-pounds. It would therefore take 36.6 Chinamen to yield a continuous horse-power and the wages of these Chinamen would amount to \$3.66 per day, or \$1,336 a year.

From Niagara you can buy a horse-power year for \$20. It costs the paper mills which have their own power about \$12 a year for continuous horse-power. Human energy at \$0.10 a day costs one hundred and ten times as much as this water-

power energy, although the supervising human labor receives an average of \$3 a day.

The substitution of uncarinate energy for human muscular energy has increased wages thirty-fold and has cheapened power to 1 per cent. of its cheapest muscular price. This is not all. When men are used as power generators the supply is strictly limited and can be easily monopolized. Uncarinate energy is without limit as long as there is coal and oil and gas, as long as the sun shines and makes organic fuels or draws up water from the surface of the ocean.

For strictly limited horse-power at \$1,336 a year we now have unlimited horse-power at a minimum price of \$12.

We have brought about this gigantic change in conditions not by adhering to routine but by abandoning it. This example could be paralleled in every direction.

The ability to use without limit cheap power has revolutionized all conditions. To spade up a section of land would take an active man's energy for 500 years. With oil power tractors and gang plows three men can turn over 640 acres of land in 36 hours. It is good hard work to make a broad jump of 20 feet at a speed of 10 miles an hour, rising 4 feet from the ground, but aeroplanes at the international contest this year will fly 80 miles at a speed which may reach 110 miles an hour, and fly as easily at an altitude of 5,000 feet as at 50. Formerly a man could carry a maximum load of 100 pounds; to-day his trains drag 6,000 tons and his ships carry 30,000 tons. Formerly a man's voice carried 500 feet; now as he sits at his desk he can reach with his voice 20,000,000 people, some of them a thousand miles away.

I do not consider myself an old man, yet almost nothing of engineering importance to-day was taught when as a youth I went to one of the foremost technical schools in the world, and almost nothing that I there specifically learned has any value to-day. I learned from Weisbach's great work how to design Dutch windmills and overhead water wheels, but not a word of dynamos or motors, of telephones, of gas engines or of gas producers, of storage batteries or of aeroplanes. I

was trained looking backwards into the past. I was not trained for what was ahead of me.

There was never a period since the world began when man had so rapidly to abandon the practices of the past and to put his trust in what his father and mother knew nothing about.

The changes in the last fifty years have therefore scrapped most of the technical experiences of the past and have profoundly modified moral obligations.

Our parental training, our religious training, our school training and our social training have been governed by the ideals of the routine past. Although progress absolutely depended on initiative and to a very small extent on routine, we have not been equipped morally, mentally or physically to do good original work.

Much of Socialism, for instance, rests on the assumption that the good things in the universe are strictly limited in quantity and if any man has more than the average he must have robbed somebody else. The same assumption underlies the aspiration for suffrage by women. If anything was ever a routine survival from the foolish past it is the idea that suffrage is a panacea. I would give suffrage to those who want it, as I would give away a worn-out garment. Far more important than suffrage is the realization that the home, the school, the church and the ball-room, where men and women work side by side, are cleaner and more efficient than businesses managed by men alone.

The good things in the universe are not limited. The telescope shows that there are billions of suns in reserve, most of them larger and finer than our sun. We have reached out with our nerves of sight and rescued these suns from the bottomless void. We may in time harness their heat for our service, even as we now make the oscillations of the ether carry our messages. Grand opera is no longer limited to the rich, nor moving scenes in distant lands to bold travelers. The phonograph, even making alive the voices of the dead, brings into the lone, cold, winter camp in Northern Alaska

a wealth of music which twenty years ago no emperor could have commanded. A tramp, for the price of a beer, can sit in comfortable, cool and restful darkness, watching living scenes out of the long ago, scenes that not even the greatest traveler could formerly have witnessed.

It is not true that the few are growing richer because they are impoverishing the many.

It is true that our greatest men, the men to whom on account of their initiative we owe most, were not trained to use their great gifts. They received a routine education, and as they found it of no use, like children who have found a box of matches, they did not know how to use the blessing of fire.

The old rules of the road, the turning to the right, the halt at grade crossings to look and to listen, the speed limit of six to eight miles an hour, cannot be applied to aeroplanes, yet we have tried to keep our Rockefellers, our Carnegies, our Harrimans, our Hills, within routine bounds. We have not even advanced to the state of using modern devices. We are still teaching our children to read fairy tales instead of watching moving pictures; we teach them to write instead of training them on typewriters; we painfully drill into them multiplication tables instead of initiating them into the mysteries of the slide rule; we teach them to add and subtract instead of drilling them on comptometers; we teach them to draw instead of carefully training them to use photography; we have them drum for years on the piano even if they have no musical ability, when they ought to be trained to put a soul into mechanical records.

What is the fault of the whole educational system? As is always the case, when routine is placed above initiative, we are relying on methods and devices and systems instead of on principles; we codify our laws and add countless new ones instead of branding every one of us with the fundamentals. So absolutely unprepared are we by past training and teaching that we would have great difficulty in agreeing as to what the fundamentals are. The need of the age is clearly

to see and practice, not a Christian era conception, nor a Crusade conception, not a Reformation conception, not an American revolution conception, but a twenty-first century conception of the golden rule, of ethical ideals worthy of the telephone, wireless, gas engines, aeroplanes and radium. The new era must produce a new man. Will he prove a Frankenstein?

I have no right to assume that I can see further into the starry night ahead than any other on the lookout, but it seems to me that what we most need is to come to some understanding of the relative responsibilities of individual, of corporation and of state.

The collective average is always weaker than the best units. The average duration of human life is determined by a means in which the shortest has as much weight as the longest. The average wisdom of government is the mean between the fool and the wise man. The way to better man in the aggregate is not to lessen the responsibility of each unit, but to increase it; to bring, from within, the poorest units up to the level of the present best and to have the present best establish a higher standard.

What is the particular application to engineering schools?

Engineers more than any others ought to be able to appreciate the value of initiative. The courses in the engineering schools ought to be modified so as to develop initiative. Engineering students ought to be taught to distrust all the traditions of the past. The engineering teacher ought to warn away from anything that has already been tried out. The assumption ought always to be that "what is" is probably wrong, and the absurdities of "what is," for instance, a locomotive engineer on the tail end of the engine, ought to be unmercifully pilloried. The student ought to be taught to guide himself, not by landfalls and landmarks, but by the eternal stars. It can be done and it is the duty of teachers of engineering to do it.

PRACTICE VERSUS THEORY IN THE SCIENCE OF MANAGEMENT.

BY FREDERIC A. PARKHURST,
Organizing Engineer, Detroit, Mich.

It is not the author's intention to imply by the title of this article that practice and theory do not each bear a most important part in the science of management. These two words are symbolic of two chief factions, one for and one against our new science of management. To the layman, scientific management is a theory, pure and simple. To the manufacturer, who has put his plant under this form of management, it stands for prosperity to the firm and all its employees, a new era of industrial peace and contentment, low costs and high wages.

It is not at all remarkable that there should be such a wide difference of opinion on this subject. It would indeed be remarkable if it were not so. History repeats itself. What is now true of scientific management has been in the past true of all great steps or changes, tending to the advancement of the human race. The march of progress in all things would cease were there no obstacles to surmount. Columbus, Watt, Ericson, Morse, Marconi, Langley, Chanute and the Wright Brothers, as well as many others, were each and every one at first considered theorists or cranks. Their dreams of the possibilities of their chosen lines of work at first seemed ridiculous to their contemporaries but the practical application of their ideas has far outstripped their broadest conception of these subjects.

There is no doubt that the new science of management will come into its own through exactly the same process of transition. The few chief exponents of scientific management are in exactly the same position as were the inventors and investi-

gators mentioned above. No one can deny that the field of the organizing engineer opens into vast fields of progress. The benefits which will accrue from the universal application of the new science of management will affect in a greater or less degree all of the working class in this country, eventually the world. The author once predicted that the science of management was "slowly but surely becoming universal in this country." That was nearly eight years ago, and he now reiterates the same prophecy. In fact, the striving for efficiency in life as well as business is becoming universal much faster than any one, except the best informed, realizes. This is primarily due to the fact that in the last year or two, scientific management has been prominently brought to the attention of the entire country on several great occasions. Chief of these are:

1. The Interstate Commerce Commission investigation last year into the proposed increase in railroad freight rates.
2. The formation in New York, December, 1911, of the Society to Promote the Science of Management.
3. The conference on scientific management at the Amos Tuck School of Administration and Finance at Dartmouth College, in October, 1911.
4. Formation of the Efficiency Society in New York, in the spring of 1912.
5. Congressional Committee's investigation and report on the Taylor and similar methods of scientific management.

In addition to the above mentioned events there has been a general exploitation and discussion of the subject in nearly, if not all, of the trade journals, monthly magazines and society transactions, to say nothing of the newspaper reports, etc. All of this publicity has of course had its effect. Fortunately and justly, the majority of the articles and discussions have been favorable in their attitude. The few which have not been so were obviously written by persons scanning the subject superficially or with distorted vision.

I am sure that all the chief supporters and exponents of scientific management will join me in heartily inviting a

thorough and impartial investigation of its principles and the results which follow a practical application of those principles. Such an investigation is the easiest, most logical and surest way of enlightening oneself on the subject. It is unfortunate that a number of would-be critics have apparently not made a thorough and impartial study of this subject "on the ground." They have evidently passed the door and guessed as to what was within. They have a perfect right to guess, form their own opinions, etc., for their own personal satisfaction. When they attempt, however, to exploit their supposed knowledge of the subject to the detriment, intentionally or otherwise, of those directly to be benefited by the adoption of scientific management, it is time they and their followers become enlightened.

There are undoubtedly many "theorists" who believe that scientific management can be studied, rehearsed and memorized in the school room or library and "presto!" an efficiency engineer is born. It must be acknowledged that many efficiency engineers have sprung into the field in just this way. They are full of theory but not *the* theory, and without the practical knowledge of their subject or of *men*.

Many theories may of course be formed by as many different men. These theories but reflect the scope of each man's imagination or grasp of the fundamentals. There may be many theories as to scientific management, what it is, its scope, value, etc. That these theories vary so widely is but natural. They are due entirely to a lack of understanding, or full comprehension of the fundamental principles. Mr. Fred W. Taylor defines scientific management as a combination of the following elements:

- A. "Science, not rule of thumb."
- B. "Harmony, not discord."
- C. "Coöperation, not individualism."
- D. "Maximum output in place of restricted output."
- E. "Development of each man to his greatest efficiency and prosperity."

Many people consider the above combination of elements a

theoretical proposition which works out easily on paper but will not resolve itself into a practical solution. Let us analyze Mr. Taylor's principles separately:

A. "Science, not rule of thumb." There has been much criticism of the word "science" or "scientific" as applied to the problem of management. Many critics claim that there can be nothing scientific in works-management and that the word so used is incorrect. Webster's definition of science is: "Systematized knowledge of the conditions and relations of mind and matter; accepted facts and principles as demonstrated by induction, observation or experiment." If systematized investigation and compilation of data pertaining to knowledge of the conditions and relations of mind and matter do not represent the most important feature of proper management, then what does? A common-sense method of proceeding with each piece of work is to find

- (a) What must be done.
- (b) What material used.
- (c) How must it be done.
- (d) With what tools.
- (e) How long will it take.
- (f) When will it be done.
- (g) What will it cost.

To answer these preliminary questions satisfactorily one must have a complete knowledge of the equipment and material involved, of the qualifications of the individual workers and of the various other elements entering into the completion of each piece of work. This comprehensive knowledge comes through specially trained men, detailed to carry on and record all investigations necessary. It is most certainly in line with scientific methods of procedure.

B. "Harmony, not discord." It is needless to say much in the way of advocating the desirability of harmony over discord. This of course is axiomatic and there can possibly be no sustained criticism of such a feature in any form of management, whether scientific or otherwise.

C. "Coöperation, not individualism." Another common-sense element which allows of little controversy.

D. "Maximum output in place of restricted output." A concern to be successful, and to run its business profitably, must realize from its equipment and working force a maximum output and each must maintain that condition if it hopes to stay in business in the face of modern competition. The country is suffering to-day from over equipment in the way of plants and accessories. The result shows a great waste both in first investment and indirect charges including depreciation while the plant is running, to say nothing of the great overhead charge and depreciation in slack times when the plant is lying idle. Why deny that maximum production is too often striven for in a most unintelligent way? As far as the personnel is concerned, maximum production can only be obtained by surrounding them with the elements mentioned above—science, harmony and coöperation.

E. "Development of each man to his greatest efficiency and prosperity." Here again we have an element which should need but little argument in support of it. In point of fact, however, we often find opinions to be diametrically opposed to what we would naturally expect to find. The trouble, however, is not with the principle involved or with the theory that it is a desirable and necessary thing to strive for—this maximum efficiency and prosperity. The cause is often a lack of knowledge of what is involved and a deplorable misunderstanding of the objects and intentions of those striving to bring about maximum efficiency.

I have discussed these principles at some length and many may think I am going over ground which has already been covered. My object, however, in doing this is to again bring before those who have not clearly analyzed the principles of scientific management what is involved and just what the ideal is. There has been too much taken for granted on the part of some critics. The result has been a certain factor of opposition, which is wholly uncalled for. May this resumé help to clear the subject.

One of the common criticisms heard is to the effect that "scientific management may do for some kinds of work, but

it will not do in ours." The exponent of the science of management must ever bear in mind that he faces an educational proposition continually. It is easy to condemn something which one does not understand. This being an admitted fact and bearing in mind that many of the persons directly affected by the introduction of scientific management are not in a position to understand these things, it behooves every organizing engineer to pay special attention to this one feature—namely, education.

In considering the educational feature one must not overlook the psychological element involved. To the author's mind this is the most important factor in the successful installation of the science of management, and is the one thing which has made failures from what would otherwise have been successes. That such failures have existed cannot be denied. It is equally true that the trouble has never been with the principles involved but usually with the general unfitness of those attempting to carry out the work. Other failures can be traced to the attempt to copy and install some particular feature of scientific management without the rest of the elements necessary. Men attempting to do this usually have a superficial book-knowledge of the subject and are wholly lacking in the true conception of the ideals and principles involved. *Practical shop experience and the ability to handle men* are absolute requisites for the successful introduction of the principles by any engineer.

Before taking up in detail some examples to illustrate the difference between the theoretical feature, or the bare outline of principle, and the practical method of installing those principles, I want to emphasize the fact that it is not so much *what* you do in the way of radical changes as in *how* you make them. Again I repeat that the true conception and realization of the psychological element and its bearing on every branch of management work must be recognized as the most important of all the elements. To be successful the organizing engineer must master the psychological feature of each and every problem first, last and always.

Now as to the methods used in the practical application of the above mentioned principles, the organizer must thoroughly acquaint his client with what is involved in order to realize from these principles maximum results. Stockholders, directors and officers of the company must be informed as to what may be expected in the way of results. They should thoroughly study all phases of the problem and try to realize the difficulties likely to be met. Not the least of these will be the idiosyncrasies and biased ideas of some of the personnel. The fact must not be lost sight of that at least some of the older and most valuable employees must be patiently and carefully weaned from some or most of their old traditions and habits. Those of the old school must not be blamed if at first they show ignorance or disapproval of radical changes. Their environment and training is responsible for this frame of mind. These same men will be the most enthusiastic and the strongest supporters of the new régime when they begin to see its advantages. They will be the first to show a new and lasting sense of satisfaction and contentment with the elimination of friction, the maintenance of schedules and the increased results easily accomplished with a minimum of mental and physical outlay.

The period of transition is often a long and annoying one for all concerned. This is due to the many variables to be overcome. Patience and tact will win out in the end if each and every one realizes that every one is human after all. Time is the essential factor, and the time required depends upon the mental attitude of each. The author to-day enjoys the friendship and coöperation of many men now working under scientific management, who at first opposed him at every turn and condemned new methods before sufficient time had elapsed to prove their worth. Men must be shown, educated, led, not driven. It is only the extreme case where in the end a man has to be removed for failure to abide by the new order of things. Study each man's character, find the avenue of approach and he can be educated and made efficient in spite of himself. Many men, particularly those in the more

responsible positions, have a natural and deeply rooted antipathy for being shown by others. They wish to be known and recognized as the originator of all that is new or an improvement over the existing order of things. It has been my experience that one of the best and surest ways of handling persons of this make-up is to accomplish the desired end through suggestion. In the majority of cases a few words followed judiciously with concrete examples to illustrate your point will sow the seed of desire. This seed will immediately take root and sprout forth as an original and newly discovered method *sure* to meet the exigencies of the occasion. This method will not do with all men of this mental attitude. Some will not be influenced or convinced until shown by actual accomplishment. Others can be recruited by the proper presentation of the results of an analytical study of conditions followed by cold, impartial figures. Figures talk, especially if they are always recapitulated into a bare statement of value in dollars and cents.

Other men will be found in every organization who have an inherent faith in any new departure ordered by their superiors. Such cases do not offer the same kind of handicap, as do those above cited. They do offer another possible source of trouble however: that of a too earnest wish to reach the desired goal, without due appreciation of the difficulties and conditions to be overcome and changed. Material difficulties can be removed with comparative ease. Changes directly affecting the personnel are often far from easy and continual restraint must be exercised for this reason. If this restraint is not present the too enthusiastic department head or some subordinate will find himself opposed by a stone wall of personal opposition. Many men can be led but only the few can be pushed.

Education of the rank and file is fully as important as the education of the principals and heads of departments. The education of the former is much easier, however, when the latter have graduated, so to speak. Let those at the top set the example. Shop men as a rule have the erroneous idea

that their superiors and office force are inclined to consider themselves on a much higher plane and seemingly force themselves to the necessary intercourse with those beneath them. There is no doubt but that in many cases this condition exists. That it is often so is most unfortunate as well as unnecessary—and most undesirable. One of the greatest advantages of real scientific management lies in the fact that such a demoralizing and disastrous condition of affairs is eliminated. I do not mean to imply by this statement that scientific management is the sole remedy for such a condition, but it is nevertheless a *sure* remedy. In point of fact, under scientific management the rank and file are placed in position to demand and *get* from their superiors proper working conditions, and as to maintenance of equipment and supply of material, to get coöperation, and the “square deal.” Responsibility is placed where it belongs. No one high or low can “put it over” on another, because the responsibilities and duties of each are clearly defined in writing. The pressure of responsibility is not one sided and concentrated in one place, or directed towards the weak. It is equalized. Instead of turmoil and contention like the troubled and restless sea, which makes smooth running impossible, we have the calm and reliable medium of a harbor sheltered by the bulwarks of harmony. The least opposing influence immediately becomes apparent. It can be localized and remedied at once.

The best influence is an honest confidence in the entire personnel. An efficient organization with reliable heads and a spirit of coöperation in touch, through these mediums, with all of the personnel, lays the foundation for a lasting and trouble-free industrial or business condition. To bring about these conditions eternal vigilance is necessary. No one must be allowed to harbor any misunderstanding as to the intent of the reorganization. Investigate and trace to its source every disturbing influence. Let no one misunderstand the ultimate object in view. Openly advertise and propound the chief elements or principles of our new science of management.

A. SCIENCE, NOT RULE OF THUMB.

Having observed the above essentials, the next step is to bring under control equipment, methods and output. This has formerly been left to the foreman and bosses. Details and responsibilities have been thrust upon them which should be borne by others. Specialization is the order of the day under scientific management.

The modern planning room is the first really radical innovation. The production clerk, order-of-work clerk, route clerk, material boss, shop engineer, time-study man and speed bosses, are new functional men. These are created to take off of the shoulders of foremen and others, duties for which they are specially trained. Through this department we begin to control shop equipment, methods and material.

The different planning-room men begin through analytical study of conditions to determine the shop conditions. Work for the shops is planned and distributed in the most efficient way. Delays due to faulty equipment are investigated and a recurrence made impossible. Equipment is tuned up, cared for and kept in repair. The result is that each machine and man is made more productive. There are no waits or delays on account of absence of material with which to work. Some men or machines are not piled up with work while others work from hand to mouth. The work ready for processing is evenly and judiciously distributed. I have known of cases where one third ($\frac{1}{3}$) of a day of man and machine, often of gangs of men, has been wasted, due to such causes. This condition is common; the effect is demoralizing and tends to gradually decrease the daily output per man. Over equipment due to lack of planning and to pure guesswork is also largely responsible for a decreased output per capita. Production clerk, order-of-work clerk, route clerk, and material boss remedy this.

Having provided for the maintenance of standardized equipment, conditions and flow of material, the methods must be investigated. The shop engineer determines the tools and methods; the time-study boss determines the standard time,

and the data is available for the issuance of instruction cards. The speed bosses then see that the instruction cards are followed and the standard time realized.

It will be seen by the above brief explanation that what is ordinarily done by one or two men is done under scientific management by six or seven or more, depending upon the kind of business. What is the result? Each of the chief planning room men becomes highly proficient in his particular branch. Through them it is possible to itemize and analyze into small elements all details of a business. They have complete and up-to-date records of all work which has been done. Comparison can be made, both of methods, quality, *time* and cost. Relative capacity of machines, men, productive units and departments can be made, and work planned and distributed accordingly. Elemental operations can be standardized, and men can be trained to do them in standard time with a minimum of effort. Each man's efficiency can be kept track of and his work and *pay* regulated, independent of his fellow workmen. The accumulation of data makes possible the correct determination of how much men as well as machines can do daily without undue fatigue and eventual break-down. We can safeguard our machines by not overloading them, because stresses due to tool pressure, torque and vibration, can be controlled through instruction cards. Fewer accidents will occur on this account because detailed study of operations determines the best and safest way to do a given piece of work. Not many people realize how comparatively few different elemental operations are actually necessary for the performing of all kinds of work in any one trade, until they have analyzed and studied them personally.

Consider the above carefully and then answer the following questions for yourself. Can any foreman who is in charge of the average sized department with all its variety of equipment and its twenty-five to fifty or more men, keep track of all the above elements and so obtain maximum efficiency? Were he mentally and physically capable of all the work necessary, could he be an expert and highly proficient in so many different

lines? Could he even find time to both plan and execute on the scale required? Would he be in possession of the data necessary to absolutely control methods, conserve the time of each man, eliminate delays, etc.? Could he be always fair and just and impartial in handling his men? The answer is most emphatically *no*. A jack of all trades is master of none. Yet ordinary management often demands of its foreman *all* of the above and more.

What will the planning room accomplish for a concern? Combined with bonus system of extra remuneration, it will result in doubling, tripling, and sometimes quadrupling the output of a plant. It will reduce labor costs, including the extra overhead from 30 per cent. to 50 per cent. and increase wages from 35 per cent. to 50 per cent.—in some cases even more.

A word will not be out of place regarding obvious advantages of these methods in setting correct rates. It is not unusual to find piece or premium rates set by the usual guesswork methods that allow a man to earn \$7.00 to \$8.00 per day for much less return than represents a fair day's work. I have known of several cases where a piece rate was cut nearly in halves because the man was earning about \$8.00 per day. After the cut he still earned \$8.00. Obviously the original rate was four times what it should have been. The work did not require skilled help and \$4.00 per day would be a generous wage. Aside from this, the man was limiting output during the time he was making on the original rate. He doubled his output when the rate was cut. Had stop watch observations been made by a properly trained time study man, preferably one who was skilled in the trade under observation, this could not have happened. The result of improperly set rates need not be discussed here at length. They include dissatisfaction on the part of the firm; the inevitable cut and continual dissatisfaction on the part of the men; limitation of output; increase of discontent and deceit and eventually labor troubles. The elimination of these troubles will save many times more each year than it costs to run a planning room.

When a foreman sets a rate, he estimates it by using day-work output as a basis. He adds something to it for luck and sets his rate. Actually the rate of day-work under ordinary shop conditions as compared to bonus work under scientific conditions is 1 to 3 or 4 on the average; some cases 1 to 10 or even more.

There are certain difficulties to overcome when establishing bonus in a plant accustomed to piece or premium improperly set. These difficulties consist chiefly of a marked difference in the maximum earning power of a man based on a bonus rate set after an itemized time study, as compared to the arbitrary piece or premium rate. The preceding paragraph has explained in part what these differences are. In addition, however, to the difference in the ultimate day's earnings, more trouble is met with in trying to educate the workman to an entirely new viewpoint. This can best be explained by calling attention to the fact that what we purchase is a man's time and not his output. It is up to the organization to see that a fair output per day is realized. When this output reaches a fair average maximum, the extra remuneration is in the form of a bonus, the result being an increased daily earning. Comparing a differential bonus scale of prices, however, the tendency on the part of the man is to consider it only as a piece rate. To further illustrate this point, if we have a job that has been paying seven cents (7 c.) a piece and the production has been about fifty pieces per day, the piece rate earning of the man is \$3.50. If this method of payment is replaced with differential bonus, the tendency is to compare the difference in earnings of the day for the last few pieces. The result is that the man feels he is being paid at only the rate of say, two cents (2 c.) a piece, losing sight altogether of the fact that he has been assured of his nominal day rate irrespective of his production.

The above mentioned troubles are not found where improperly set piece or premium rates do not exist. Neither is there similar trouble in establishing bonus rate in a shop which has worked only under regular hourly or daily wage. One often

has to contend with the natural antagonism of some men who feel that the installation of bonus is some means in disguise of further reducing their earning power. This objection, however, can readily be overcome after the men realize that the rates will be established correctly in the first place, and remain unchanged so long as the piece or job remains unchanged, in design, method or equipment. Of course guaranty not to change rates would as readily apply to piece or premium work under like conditions. The trouble, however, is that piece or premium work is usually priced arbitrarily and so results in unfair rates, both to the man and to the firm. Therefore, it is practically impossible to guarantee any permanency.

B. HARMONY, NOT DISCORD.

This is the second element of the combination defined by Mr. Taylor. How often we hear the criticism that harmony is realized in almost all lines of business and that it has nothing whatever to do with, neither should it be particularly identified with, scientific management. If this is so, and if harmony is such a well-understood and common element, why don't we see more of it in the average manufacturing or industrial establishment? The fact remains that in a great many instances, harmony is conspicuous by its absence. Many of the chief reasons for this condition can be traced directly to the case illustrated in the last few preceding paragraphs. Its absence is often due to that great variable the personal factor. This is particularly so in large plants which have grown rapidly and abnormally. Their sudden growth has demanded the mushroom type of organization which must of necessity lack the refinement of one more deliberately planned.

There are a great many factors tending to create discord, some of which require an immense amount of time to remove. As far as the personnel is concerned, this can be handled and developed in the way previously referred to in this article. When that is accomplished the next move is to inspire everyone with the policy that only the square deal will prevail.

To bring about this condition, extremely strict order of discipline must be maintained and the policy of the company clearly defined so that everyone can work in harmony with it. Each member of the organization must be forced to realize the fact that everyone is employed to work for the company's interests, and coöperate and work in harmony with his associates. Discrimination of individuals must be absolutely prohibited. This latter dictum is one likely to be far-reaching in its nature. Men have to be trained to lay aside their personal likes and dislikes and to regard their work from an entirely different viewpoint. This is hard at first, but after they become accustomed to the new order of things and begin to realize the certain advantage, it is as natural to work harmoniously as otherwise, and much more comfortable.

One of the greatest disturbing elements in connection with building an efficient and harmonious organization is the one of poor pay. It is a mistaken idea on the part of many managers and heads of departments that they are earning money for the company and running their department cheaply by the employment of cheap help. This is as true of office employees as it is of the rank and file. The layman little realizes the actual difference between output per man as compared to large differences in pay per man. For example, many cases can be cited where a man earning \$2.50 has an output which can be expressed by unity; by an expenditure of more money for sufficient supervision, proper maintenance of equipment, etc., plus extra incentive to the man for following instructions and putting up a fair day's work, a production can be realized which may be expressed by 3 or 4 and sometimes much more.

The difficulties in the way of remedying this condition while promoting harmony are very many. This statement may seem strange, but it is nevertheless true. In many cases the greatest objection comes from those who are eventually to be directly benefited by this change of condition. The average shop man presents another stumbling block by considering his own particular work more or less his private asset, of which the firm

should know little or nothing. In other words, he feels that the more dependent the firm is upon him for information, the more secure his position with them will be. The fact is lost sight of that promotion is often denied a man because through lack of organization and knowledge on the part of the firm, he is forced to remain in a minor position. When data of each man's ability is in the hands of the firm, advancement can be made commensurate with his ability without in any way tending to disrupt or retard his work or that of his department. In order to bring about this condition and establish a self-sustaining organization, each incumbent of important positions, including heads of departments, should train and have immediately under him a successor competent to take over his duties and responsibilities at a moment's notice. This condition can pertain to a small organization as well as to a large one. A man may often fulfill the duties of several positions where the duties of one do not require all of his daily time.

C. COÖPERATION, NOT INDIVIDUALISM.

This element in a general way can be considered in the same manner as harmony. Individualism in the ordinary form of management can be likened to coöperation under scientific management in much the same way as individual effort among a body of men can be compared to well-trained and highly-organized team work. Our modern professional baseball team is probably one of the greatest examples of scientific management before the world to-day. The fact is little realized by the thousands of enthusiastic fans who watch one of our league games. Great enthusiasm is often manifested over some startling or spectacular play on the part of an individual which may appear to be absolutely spontaneous. The truth of the matter is that the majority of such plays have been carefully worked out by long and tedious practice and intricate time studies. The result is that with the player on base and the ball in a certain part of the field, or in the hands of a pitcher about to be played, the success

of the proposed play can almost invariably be predetermined. This has been brought down to an exact science.

It may seem ridiculous to say that the modern battleship is handled and controlled by a planning department; nevertheless this is exactly true. The handling of a battery of large guns in record time and the percentage of hits which ten years ago seemed absolutely impossible, involves the coöperation of a great many different men. The use of highly perfected instruments, combined with the predetermined condition of the atmosphere, variations and speed of the wind, weight and condition of powder, etc., all enter into the problem. In the report of the battle of Santiago, our patriotic and enthusiastic populace marveled at the feats of gunnery and marksmanship displayed by the United States battleships. The truth is that to-day it would be considered a most disgraceful exhibition. Only five per cent. of the shots fired at Santiago reached the mark and at comparatively short ranges. To-day, under like conditions from sixty-five to seventy-five per cent. of the shots would reach their marks and at ranges mounting as high as eight or nine thousand yards, and at speeds double those involved in 1898.

In industrial establishments like comparisons can be made. Investigation will show an immense amount of duplication between departments. Similar operations in like trades will be found to vary widely in method and more widely yet in time consumption. Each journeyman has his own particular idea of how his work should be prepared, how his tools should be forged or ground, and the condition of the material with which he works. Thus these elements become great variables because the whim and biased notions of the individual make them so. Standardization of these elements greatly simplifies them. Lack of unity of purpose and ideals results in the individual limiting himself and his chances of advancement as well as limiting that most vital of all interests, his earning power.

Complete coöperation and unity of men, methods and equipment will revolutionize the entire tone and capacity of a

plant. Where departmental functions, both as a whole and in detail, do not thoroughly dovetail into a harmonized whole, friction and disruption will exist. It is a well-known fact that we are not to-day, as a rule, turning out the high-class, all-around mechanics that we did years ago. The reason for this is obvious, although the remedy for it is not so obvious to the layman. There can be no dispute over the fact that scientific management favors the apprentice, handyman and journeyman rather than the firm itself. When organized labor realizes what scientific management actually is, they will find they have much more to gain by coöperation and acceptance of its principles than they can hope to gain by any other method. This statement can be easily proved by investigating the plants working to-day under its form of management.

It may be well here to cite a remark made by the superintendent of a large and well-established industrial plant in the East. In speaking to one of our noted efficiency engineers of the work which was being accomplished, he said that his firm would be thoroughly satisfied if the only benefit they realized from scientific management was the increased wage and higher moral standing of their men and the attendant prosperity which would accrue from the change. This statement expresses a sentiment which many of the laboring class cannot acknowledge exists on the part of the manufacturer. Such sentiment is growing, however, and that the fact is not more fully realized by the working man is to be regretted.

D. MAXIMUM OUTPUT IN PLACE OF RESTRICTED OUTPUT.

Reference has previously been made in this article to the ratio of production under ordinary management to that under scientific management. A great part of this is due, of course, to the change in organization, plant methods, etc. The balance is due to the increased effort and interest exhibited by the men, encouraged by a higher average of wage. The natural incentive on the part of the men is lacking un-

less all elements referred to are present. As soon as a betterment of condition has been realized, men are mentally in a different attitude, and will naturally exert themselves to earn the additional compensation.

The demoralizing effect of incorrect rate setting cannot be over emphasized. It tends to promote a disposition to deceive and restrict output. Such a condition naturally breeds discontent and lack of confidence in the management. One must rely largely on the individual's tendency to better his own condition when the opportunity presents itself. When the man learns how to produce his maximum with the prospect of a definite and immediate reward, he finds more pleasure in his work. He is mentally in condition to aspire to do the best that is in him and he develops the natural pride which is more or less latent in everyone.

E. DEVELOPMENT OF EACH MAN TO HIS GREATEST EFFICIENCY AND PROSPERITY.

This development comes as a natural result of the preceding elements working in accord. The highly-trained and efficient men receiving a large weekly pay make better citizens than the inefficient and underpaid. They are enabled to do better for their families, as to housing, clothing, and feeding them, and they are enabled to give their children better education. There are many children of to-day denied the education that belongs to them with the result that their entire after-life is handicapped. They are denied the advancement and opportunities which are more and more becoming subject to the individual's mental development. If the little red schoolhouse is to represent one of our chief constitutional pillars in which we take so much pride, it must be supported by a high standard of American citizenship. What this really means can only be fully appreciated by the study of home conditions in a largely foreign community employing low-grade and comparatively ignorant help. The development of a healthy mind and body while young is the only possible mainstay to a cosmopolitan nation such as this

United States is growing into. As efficiency will bring about the increase in wages, so it will ultimately result in the decreased cost of the necessities of life. In other words, when we become universally efficient, both individually and collectively, in all walks of life ranging from the farm to the banking house, our net return per capita is going to be greatly increased.

We must make radical changes in most of our traditional ways of doing things and we must realize a new standard of ideals. This can only be brought about by a long and painstaking course of hard knocks and experience. Students of this subject should study it from the practical standpoint and by close detailed investigation of its actual workings. It is not in any sense a subject to be learned from books, but one which must be learned from close contact with and thorough understanding of the personal element involved. Only in this way can the psychological conditions be fully appreciated and understood.

EDUCATION AND EFFICIENT LIVING.

BY MEYER BLOOMFIELD,

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Mankind has passed through various "ages," picturesquely described by the historian as the ages of steam, of iron, of steel, of electricity. But all indications, all the signs of the day in which we find ourselves, the industrial unrest, the changes in our legal and political institutions, the acid test of organized enterprise through scientific management, and the transformation of our educational policies, point to an age which transcends in value all the historic ages preceding—*the age of man*—that period in which society sets out to discover how the energies of men can be liberated for the most effective living, livelihood, and social service.

To the engineer and to the methods of our technical schools, the social reformer and the progressive educator owe a larger debt than is generally recognized. The antiquated idea of education as the privilege of a fortunate few, enjoyed for the most part in a cloistered aloofness from the problems of common life, has been fast crumbling away under insistent modern demands for democratic training of "all the children of all the people"; demands arising not only because of the necessity for civic self-preservation, but also because a truer understanding of human capacities makes us all impatient with the present waste of gifts, talents, and human possibilities.

We have been so busy trying to catch up with our tasks of spreading the common schools, lessening illiteracy, and promoting good citizenship, that we could not pause long enough to consider differences in human nature and the fundamental importance of differentiating our approach to each individual. In times of stress and emergency we do not inquire too closely into personal merits. All must be dealt with alike, all who

seek must be supplied. When normal conditions are restored, however, more scientific methods must be followed or the resulting harm may far outweigh the good. So with our schools. As the basic need for the elementary instruction of the masses in elementary subjects is met (and there is yet much to be done in this country) then stock-taking and a scrutiny of methods and accomplishments become a part of intelligent administration. During the extension of popular opportunities for schooling, for several decades past, there have developed the modern schools of applied science and the specialization in the engineering branches. No greater contribution to educational progress has come during this period than in the lesson, taught by these schools, of the value of the laboratory and of contact by the student with things as well as with ideas. "How can a man learn to know himself?" asked Goethe. "Never by thinking, but by doing."

Two purposes mark any intelligent system of training men; first, to enable men to know themselves, and, second, to enable them to find themselves. Schooling of the conventional kind leaves out most of the senses in the training scheme; it is devised for inert masses of pupils; its tools are printer's ink and the teacher's voice. President Eliot has pointed out the defect in making our schools for "listening."

This is surely a stock-taking period in business, in politics, in education. The employer has been complaining of the product of the public school. We find that nearly half the school children of the land drop out before they even complete the grammar grades. We find, too, that our system of secondary education, admirable though it is in many respects, is ministering mostly to the four per cent. or so of its pupils who go to college, and has scarcely faced the life-work needs of the vast majority who must go to work. This dropping out of school, therefore, of so many unprepared boys and girls at a time when they should be laying the foundations of vocational efficiency, is now recognized as a national calamity. Many thorough investigations, one by the United States Bureau of Labor, have shown that pressure of circumstances

accounts for only about one third of this exodus from school to work. Two thirds could have remained to further fit themselves if opportunity and intelligent organization could have been provided.

The abrupt ending of school influence for so many on the fourteenth birthday is only one of a train of evils. Dropping out as they do, their entrance into working life is no less deplorable. They do not know anything about the work they go into and they leave one job for another, just as they left school. Few have any idea of preparing themselves for a career. They drift until manhood responsibilities are upon them; then it is too late to prepare for anything. It is now known that a large part of the misemployment and unemployment problems can be traced to these early blind driftings in the uncharted employments. The school has failed to connect with the vocational needs of its pupils, has failed to take into account the probable careers and experiences of most of its children. On the other hand, the kind of work these young people go into is not of a sort to develop them, to train them, or make anything out of them. Therefore both school and job are now up for investigation. President Eliot has spoken of the "life-career motive" in education. Any education which fails to build on this most fundamental purpose, or fails to arouse an interest in it, does not belong to our militant age of effort and service. Any occupation which does not deepen and enlarge this purpose and motive, which does not in some way offer both a life and a career, is one which probably needs the attention of public opinion and the legislature.

School and work, then, must minister to the life-career motive, to the bread-winning effectiveness of our workers and citizens. The movement for vocational guidance has grown out of a deep recognition of the price society pays for the aimless driftings, the economic waste, and the social wreckage attributable to the unbridged chasm between school and work, to the unprotected and unguided transition from school life to working life. Vocational guidance looks upon both school and shop as means for investing the capacities of the young people

to their own and society's utmost good. Investment, not exploitation, is the goal. The child's good, and the community's good must be placed above all else.

Experience has demonstrated that where a school looks intelligently to the life-career there is hardly any dropping-out problem. The employer, who fulfills his responsibility, reduces his losses, which in many an establishment amounts to a turn-over of employees every four or five years. If education does not lead to self-discovery, what else does it do? In this desideratum the technical schools have been quite fortunate. They have greatly aided their students to find themselves. Are they all living up to their opportunities and their privileges? There is no little danger of complacency and backsliding on their part. Let me say that vocational training does not in itself carry any guarantee that it will not deteriorate into abstractions and academic routine, that it will not lose touch with reality. With the doors of our technical-training schools wide open, as they should be, there is no assurance that fitness alone will seek admission. Mass instruction here, as in the academic schools, is prevalent. The time for "hand-picked engineers" as a professor in one of our technical schools has phrased it, has gone by. Never was greater need than now to formulate standards and to organize a selective process for the future engineers. This plea is made not so much for the benefit of the schools and the profession, as for the young men who may be misled into wasting years on preparation for pursuits for which they are not fitted and in which they never can be happy.

The student of the vocations marvels at the unbusinesslike hiring of men in various establishments. The employment manager is supposed to be the mind-reader and fortune-teller of the firm. If his guesses turn out well he holds on to his place. How many firms can you recall which have drawn up specifications of what they need in the way of employees, drawn up their requirements so definitely as to exclude automatically those who cannot succeed? "Trial and error" is the prevailing method, with all the waste and discouragement this involves to all parties concerned.

I have not observed that the engineering callings have framed their demands so that parent, teacher, and prospective applicant can base a choice of occupation on the data set forth. Nor have I found a surplus of accessible, vital information concerning the new and most promising developments in the engineering pursuits, chosen to direct attention to the less crowded departments. Many of us believe that the engineer, the technically-trained man, will more and more rank with the most socially-advanced agencies for the promotion of human welfare, with the practitioner in preventive medicine and the trained philanthropic agent. We have only to look over the contributions to public health, comfort and efficiency, made by our institutions of applied science during the half century just passed, to realize that what has been accomplished for public sanitation, protection of the milk, water, and food supply, factory hygiene, ventilation of public buildings, and elimination of polluting wastes is only prophetic of what is yet to come. Indeed already from the field of the efficiency engineer has come, perhaps, the most important message since machinery came to do man's work, since the factory system replaced the home as a producing center. Messrs. Taylor, Gilbreth, Brandeis, and others have made the nation think. And in the field of efficiency engineering I find an analogy for what vocational guidance regards as the true function of the school and of education. The teachers are the functional foremen, the courses of study are the planned and routed tasks. The aim of all these forces should be to produce an individual equipped for the scientific management of all his endowments and resources; whose faculties are organized for economy of effort in reaching results, ease in exertion, persistence in traveling toward the set goal, and vision to understand his relationship to his fellows.

THE ENGINEER AS A MANAGER.

BY H. L. GANTT,

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The industrial developments of the past fifty years have been so great as to modify profoundly, if not to revolutionize the methods of living in the whole civilized world. If we will compare the conditions and methods of living just previous to the Civil War with those of today, and itemize these differences, we shall find that they are due in a large measure to the development in the mechanic arts.

Fifty years ago the peaceful methods of accumulating wealth were substantially those that had been in vogue since the dawn of history, and consisted of buying, transporting and selling, with the lending of money to finance such undertakings. Ancient Persia, for instance, owed its great wealth largely to its position, by which it controlled all the trade routes between India and China on the one hand, and Europe and Africa on the other.

When, however, the Greeks extended their colonies along the shores of Asia Minor to the eastern end of the Black Sea, and finally even founded settlements at the eastern end of the Caspian Sea, the conditions began to change. Persia no longer had a monopoly of the trade between the East and the West, for the Greeks had a nearly continuous water route by means of the rivers of southern Russia to their markets on the shores of the Mediterranean. The competition of a cheaper route soon awakened the Persians to their danger, which they tried to avert by the conquest of Greece. Failing in this they were themselves subdued by the Greeks, and the greatness of Persia passed away.

A continuous series of similar illustrations might be cited, bringing us down to the present time, where a situation simi-

lar to that between Persia and Greece has arisen between England and Germany.

The other time-honored method of accumulating wealth is that of Rob Roy: "They should take who have the power, and they should keep who can." This method is not only just as much in vogue today as when the tribes living in the mountains made excursions into the valleys and carried off the corn and cattle of their more thrifty neighbors, but it seems to be quite as respectable and to be carried on with far less personal risk.

In the past these two methods have as a rule been operated by different classes of people who were in the main hostile. In recent times, however, when the physical methods of Rob Roy have been suppressed, more subtle and effective ones have been developed, which apparently do not violate our time-honored laws, and which can be successfully operated in connection with legitimate trade.

Thus the already wealthy traders and bankers have been able to add to their methods those of the outlaw, and to become in the words of the great Senator Dolliver, whose untimely death was such a loss to the country, "the boldest set of buccaneers the world ever saw."

In the past the great traders individually exerted but small influence over the markets in which they bought and sold, and prices were governed by supply and demand. Today, however, in this country at least, the great trusts are in many cases able to fix both the buying and selling price of the commodities in which they deal. A dawning realization of this fact was the reason for the enactment of the Sherman anti-trust law, and is now the strongest force behind the agitation for a decrease in the tariff.

Further the enormous wealth thus accumulated has enabled the possessors in many cases to become absolute owners of the sources of wealth and the means of transportation, and their training to get as much as possible and to give as little as possible in return is doing much to increase the present industrial unrest in the world.

While these developments have been taking place, others have been going on which up to this time have produced even greater results.

The invention of the steam engine, by furnishing cheap power, made possible the factory system of today; but it was nearly a century before the engine was sufficiently perfected and the mechanic arts sufficiently developed, to make the factory system very profitable on a large scale.

Although the advance of scientific knowledge was very marked during the latter part of the eighteenth century and the early part of the nineteenth, there was a strong feeling that knowledge for its own sake was the true ideal to be striven for, and to make any practical use of it was degrading. Such men, however, as Rankine and Isherwood rose above this prejudice, and although they showed the advantage of applying scientific methods to mechanical problems, and especially to the steam engine, it was not for some years that a large enough body of scientifically educated men was engaged in this work to make any substantial progress.

Soon after the close of the Civil War the need of such a body of men was recognized, and schools were founded with the express object of teaching men how to apply scientific knowledge to industrial problems. In a few years the graduates of these schools began to make their influence felt, and the scientific methods of the engineer began to supplement the empirical methods of the mechanic.

Labor-saving devices and automatic machinery began to be developed that often multiplied many times the power of the individual to produce wealth, and almost all the machinery in use at that time has been improved and made more efficient. In the art of transportation, the steam locomotive has been enormously enlarged and perfected, while the electric motor has made possible the rapid transit of our cities with all that implies. The steamship of today has robbed ocean travel of its discomforts, and cut in half the time between Europe and America. The automobile enables

us to travel at sixty miles per hour along country roads, and the aeroplane makes possible a like speed through the air.

The developments of electricity have been more marvellous still.

The telephone, the electric light, the wireless telegraph, the long distance transmission are familiar to us all, but we realize their importance only when we consider what would happen if they were all destroyed.

These facts which are so well known are typical of the developments that the engineer and the mechanic have been making in all shops and factories throughout the country, and producing the wealth that has so much increased the splendor of our great cities in the last few years.

True to his traditions of buying at the lowest price and selling at the highest, the commercial man has continued to apply these principles to all his dealings, including the purchase of labor. The combinations, or trusts, derive their strength and profit, not from their ability to produce more cheaply, as was at first claimed, but largely from their ability to fix both the buying and the selling price.

The workmen, on their part, recognize these facts, and realize that the only effort to get a greater reward for their work is one backed by force. Hence under these methods of doing business, the growth of trusts on one side, and hostile labor unions on the other, is a natural development. Further, the workmen, realizing that they get but a small share of the increase in wealth produced by greater efforts on their part, or by improved machinery, are not only slow in exerting greater efforts, or adopting improved machinery, but often opposed to both. Thus, much of our industrial development is carried on under conditions where one party and often both are hostile to such developments, for the commercial man is also often opposed to improved methods. Such methods usually cost money to install, and he being interested only in profits, does not see any advantage in effecting economies if his competitor is able ultimately to do the same. Thus where the control of a plant is in the hands of a man of com-

mercial instincts or training, there is apt to be but little interest in effecting economies that cost money; and, as many of our plants are under such control, this condition is widespread.

Such a man too often does not appreciate differences between workmen, and groups them into classes of uniform pay, thus discouraging initiative in mechanical production, and driving it into union leadership. Under such management there does not seem to be any possible method of harmonizing the interests of employer and employee, and unless these methods are modified, the industrial unrest is bound to increase, with results which no one can foresee.

Until recently the engineer has regarded his work done, when he has developed an improved machine or apparatus, and proved by operating it for a short while that its capacity was all he claimed for it. It has then too often been acquired by men imperfectly trained mechanically, but who had the commercial instinct highly developed. Such men usually turn it over to a "cheap" man to operate, and its maintenance is nearly always looked after by a second-rate mechanic, for the commercial man can seldom see why he should have a high-priced man doing repairs.

The efficiency of the machine naturally decreases, and a factory run on these principles must necessarily be more inefficient still.

Fortunately this condition is not universal, for the advantage of having an engineer for a manager has for years been recognized by some, and the number of such is increasing. This number is not sufficiently great, nor has the engineer yet had sufficient training in the art of management to make untrue the statement, which has been so loudly proclaimed recently, that the majority of our industries are very inefficiently managed.

In as much as most factories are controlled by men of commercial instincts or training, their gauge is necessarily not efficiency, of which they know nothing, but profits, of which they know a great deal.

If we would increase the efficiency of a plant, the problem must be put up to a man who knows at least what the word means. Fortunately the man who knows most about efficiency also knows most not only about the application of science to the mechanic arts, but also about workmen, by whose side he has obtained his knowledge and acquired his skill in the use of tools. This man is the engineer. *He is the only man who spans the whole gap between the capitalist and the workman, and knows the mental attitude and necessities of each. It is on his shoulders therefore that must fall the burden of harmonizing their interests.*

As said before the engineer has too often been content when he has built his machine or plant, and his training has largely been confined to preparation for this work. Now, however, when the larger responsibility of management thrusts itself upon him, his education and training should include at once the elements of his new duties.

The greatest problem before us today is not that of developing new and better appliances, but that of properly utilizing those we have. The recognition of this fact has given rise to the tremendous interest in the subject of management which has become manifest in the last few years. Interest, however, is not enough. Knowledge must be obtained before great progress can be made.

The subject of management may be divided into three groups, management of men, management of machines, management of materials. The one to which the engineer has given the most study in the past has been the management of machines. How to care for materials and to move them through the factory as they are wanted, so that there may be no delay, has been given but little attention. This has often been left more or less to chance, and it is very seldom that we can find a proper system of storekeeping and routing material. We almost never find that material moves along its route according to a prearranged schedule. Such a schedule, however, is necessary in order to keep the workmen properly employed, and we have found that proper routing and

scheduling of material has not only done much to promote harmony and efficiency in every shop in which it has been installed, but has prepared the way for a satisfactory method of managing men.

The men are thus largely relieved of the innumerable annoyances with which they are troubled in shops without a proper system of management, and where everything is done on the spur of the moment by the direct order of a foreman.

In studying how to use workmen efficiently, we must recognize the fact that they are just as susceptible to petty annoyances as their superiors, and that as a rule they are just as anxious to take advantage of any opportunities that are offered them, if they are benefited by so doing. No sooner do we, as a rule, afford opportunities for men to show their ability and to advance themselves, than some begin to come to the front. We must not, however, expect by any system of management to produce a revolution. If we can put in a system by which the workman is benefited and enabled to utilize his powers to the best advantage, although he will gradually recognize it, we must not expect him to do so at once, for his experience in the past has taught him that his employer has no interest in his advancement and will give him only such compensation as he is forced to give. Having lived under such a condition for years, which is necessarily one of antagonism for his employer, time must always elapse before he will believe that the opportunities apparently offered him are real.

If, however, the work is done under a properly trained engineer, who recognizes the advantages of proper coöperation, and is willing to share them with the workmen, we have no difficulty in ultimately bringing him to a proper frame of mind.

Our difficulty has been mainly with the commercial man, who often seems incapable of considering anybody's interest except his own, and has not yet recognized that the prosperity of all is directly helped by the prosperity of each. As yet he

has no idea of what real coöperation means. His idea of coöperation is that of the pack, or herd, whose coöperation is for attack or defense. Geo. W. Perkins and Samuel Gompers are the most prominent public advocates of this kind of coöperation, which aims to spoil the outsiders for the benefit of those in the ring.

For that broader idea of coöperation which benefits the country and people in general, I refer you to the address of Hon. William C. Redfield, before the National Democratic Club of New York City on January 3, 1912, printed as a part of the *Congressional Record*. Mr. Redfield recognizes the fact that the civilization of today is an industrial civilization, and that the nation that first realizes this fact, and acts upon it intelligently will put itself far in advance of all the others.

In as much as it must not be expected that the commercial man will thoroughly understand this for many years, it is all the more incumbent upon the engineer to assume the responsibility for showing what true coöperation between employer and employee means.

The great development of what is popularly known as "efficiency engineering," but what might more properly be called "management engineering," is a recognition of the readiness of men having even a little engineering knowledge to assume the new responsibilities. The fact that the movement is still growing, although many now engaged in it must necessarily be incompetent, is evidence that some good is being done. How much faster it will grow, when all engaged in it have had a proper preparation for their work! This preparation it is the duty of the engineering schools to give.

In as much, however, as the peaceful solution of our industrial problems will bring far greater financial gain to the commercial man than to the engineer, it would seem to be to his interest to finance liberally such engineering schools as will undertake this work.

In the past, merchants and financiers, like nations, have been ever ready to spend money to fight their opponents, even when they realized what enormous losses these fights

involved. Now, however, when the way of avoiding such fights becomes clear, it would seem logical for them to invest a small fraction of the money needed for fighting in the only rational scheme that presents itself for the insurance of industrial peace and coöperation.

THE MEN WHO SUCCEED IN SCIENTIFIC MANAGEMENT.

BY H. K. HATHAWAY,

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Perhaps from the subject it might be expected that I would be able to work up an instruction card that would enable the would-be scientific manager to achieve, through following it, immediate and unqualified success. The best I can do, however, in that direction is to enumerate what seem to me to be the fundamental elements which, when properly grouped and combined in the right proportions in an individual, enhance his chances of success.

These qualities are:

Steadfastness of purpose.

Common sense—balance.

Honesty.

Tact.

Enthusiasm.

Appreciation of the value of facts.

Energy or push (willingness to assume responsibility).

Experience—training—education.

Humility.

Of the qualifications making up this list it is difficult to say that any one of them is in all cases more important than another. Under varying circumstances each one of them assumes, at times, preëminent importance.

STEADFASTNESS OF PURPOSE.

The man who is easily discouraged can not hope for success under scientific management. It is to this quality probably more than to any other that, after over twenty years of patient, persistent, and uncompromising struggle, the world

today recognizes that there is a science of management, and honors Dr. Taylor as its founder. With dogged perseverance he met and overcame what to most men would have been overwhelming opposition, heart-breaking ridicule, and utter lack of sympathy or even understanding from those in whose interest he labored. This quality is essential to success, both in the man who desires to apply scientific management to the running of his business, and in those who undertake the work of its installation. The former, as will be attested by owners and managers, to the management of whose business the principles of Scientific Management have been successfully applied, will have many dark moments when the undertaking seems hopeless, and when the strain imposed upon his faith by the criticism and opposition of his associates and his employees is almost beyond endurance; at such times steadfastness of purpose is the only thing that prevents the failure of the undertaking and the loss of months of endeavor.

There will be times when it is undertaken to put into operation certain mechanism essential to the application of the principles of scientific management that the scheme devised will fail to work, not once but repeatedly; under such circumstances the average man would say: "we have tried it and it won't work," and would complacently return to the old method, or proceed to try some other scheme which would in turn meet with the same fate. It is here that steadfastness of purpose is needed in the man upon whom depends the development and installation of the new system. As often as it fails to work he must straighten it out, strengthen the weak points, and start over again, persistently and patiently keeping at it until finally the scheme works.

In such cases it is usually impossible to find any specific reason why the scheme should work finally any more than the first time it is started, and in my own experience I have been amazed to find something that had given so much trouble to get going, that I almost despaired of a successful outcome, all at once, for no apparent reason, commence to work smoothly and easily. The reason for this is probably that there are

innumerable kinks and obstacles so minute that they are almost invisible which become smoothed out and removed as all concerned gain a better understanding of the scheme. This is somewhat analogous to getting a new engine or other piece of machinery worked down to a bearing.

The fact that it is easier to "let a thing go" than to make it go is, in many undertakings, accountable for their having an unsuccessful outcome.

COMMON SENSE—BALANCE.

In the last analysis scientific management is the systematic and consistent application of common sense. It is nothing more or less than common sense:

To plan what is to be done, before doing it.

To systematically keep tools and machines in the best working conditions.

To ascertain what is the best and adopt it as a standard.

The man who does not use common sense in connection with scientific management has little chance of success. One must have the right sense of proportion and the proper perspective in straightening out the numerous troubles and difficulties that arise, both during the development stage of the application of scientific management to any business, and in the operation of the business to which it has been applied.

This qualification one would naturally expect to be possessed by a majority of men, yet it is amazing to see how many men, often brilliant and exceptionally able, fail to succeed simply because they lack common sense while men of rather mediocre talent succeed as a result of its possession.

HONESTY.

Any system of management that is not honest is not scientific management, nor has the man who is not honest—with himself as well as those with whom he is associated—any place in it.

The old style of management bred deceit—largely as the

result of ignorance. For example: the workman constantly endeavored to keep his foreman or his employer from knowing how much work could be done in a given time. The foreman in turn was expected by the management to know not only more than they did about the practical end of the business, but more than any or all of his workmen, and it often took a pretty stiff "bluff" on his part to make them think he knew as much as he knew they expected him to.

The man who is to succeed under scientific management in any capacity must not be afraid to admit his own mistakes and to correct them, nor must he make pretense to know things that he does not. Workmen appreciate honesty probably more than any other quality in the men under whom they work, and it has been my experience that they meet honesty and frankness with honesty and frankness, but that deceitful practices in dealing with them engenders deceit upon their part. I have seen a number of promising men meet with failure in connection with scientific management simply because they were not honest with themselves. There is no place under scientific management for the "foxy" men or the ones who depend upon "bluff" to get them by.

TACT.

This qualification must not be confounded with vacillation. The men in responsible positions under scientific management must be firm and aggressive, but they must also be able to determine when such a course is desirable—knowing when to insist and when not to do so. It is found, usually, that in dealing with the higher officials this qualification is called into use to a much greater extent than when dealing with foremen and workmen.

By tact I mean the ability to present things to men in such a way as to interest them and secure their enthusiastic coöperation, whereas if the same thing were presented in a slightly different manner it would result in incurring opposition and animosity. The old saying that "it is not so much what one

says as the way he says it" is quite true in the matter of presenting totally new and radical ideas to men who are to be affected by their adoption. It is perfectly possible, for example, to give an order in such a manner that the one to whom it is given will feel insulted, yet the same order may be given in a manner just as unequivocal, but in a perfectly courteous way.

Avoidance of misunderstandings can be accomplished through being specific and definite in all of one's dealings with others, and would also overcome, in many instances, the necessity for the employment of what is commonly called "tact."

ENTHUSIASM.

An absolute belief in scientific management as an unqualified agency of good for all concerned is a prime requisite, and one which the man endeavoring to apply scientific management must possess in order to inspire others with confidence, and to gain the hearty coöperation necessary to success.

Enthusiasm is the force that must be depended upon to overcome inertia and to buoy up the spirits of all concerned when progress seems hopelessly slow, and everything seems to go wrong.

APPRECIATION OF THE VALUE OF FACTS.

The first principle of scientific management as enunciated by Mr. Taylor is the development of a science in the place of "rule of thumb" or traditional knowledge. Unless the one who is undertaking to apply the principles of scientific management possesses this qualification, he will, in the first place, be unable to appreciate the value of this first great principle, as well as being incapable of utilizing the science after it had been developed. Perhaps no other thing has stood so much in the way of industrial advancement as the lack of this single qualification. Innumerable illustrations might be given on this point, but it would take too much time to go into it any further.

ENERGY OR PUSH.

This qualification is as essential in attaining success under scientific management as it is in connection with any other undertaking. In developing and applying the system of scientific management to any business, the man who is directing the work must see that real progress is constantly being made at every point. He must be willing to take the initiative, and to assume responsibility, putting his shoulder to the wheel at every point that lags, and encouraging by example as well as by precept those whom he undertakes to direct.

EXPERIENCE, TRAINING, AND EDUCATION.

A college education is, other things being equal, of undoubted value to the man who identifies himself with scientific management, either in the management of an industry in which this type of management has been installed, or as an engineer in working out its application to various industries.

Practical training, however, such as can only be acquired through starting as a workman in the shop and progressing to the position of gang boss, foreman, etc., is, even in the case of a college trained man, an absolute essential. Without this sort of training the graduate of an engineering school is of little use under scientific management, and, until he has acquired it, it is not fair—either to him or to those who would be under him—to put him in a responsible position where the direction of men devolves upon him.

In speaking of practical training I do not mean working a part of one or two summer vacations in a shop, but a sufficient time to master a trade—in a machine shop from two to three years. Not only long enough to acquire manual proficiency, but long enough to become acquainted with workmen, to know their point of view, to acquire a respect for them, and to lose any unwarranted feeling of superiority.

Just as the college graduate is handicapped if he lacks practical training, so is the practical man who has not had an opportunity to go to college handicapped. Either one,

however, can overcome his handicap if he only is willing to make the necessary sacrifice in order to do so.

The judgment and foresight that enables one to get results without a pitched battle, to start at the source in correcting an evil or in effecting an improvement that is to be permanent, can only be had as a result of experience of a practical nature. As a matter of fact most of the other qualifications that make for success in this line are, to some considerable extent, the outcome of training and education.

HUMILITY.

The writer has seen a number of promising men fail completely, or jeopardize their chances of success through developing a case of swelled head. Humility does not necessitate being a cringing sycophant, willing to subserve one's own will and convictions to the whims and opinions of others for the purpose of temporarily gaining their good graces, but it is the opposite of the sort of "bull-headed" ignorance that leads a man to believe that he "knows it all."

It is the lack of this spirit of humility that leads some men, when placed in positions of authority, to assume an air of superiority toward those working under them, and to disregard the laws of decency and courtesy that they observe when dealing with those under whom they work.

The great discoveries of science, and the inventions that have added so much to the world's advancement have not been made by men who knew it all.

The more one learns the more it should be apparent how vastly much more there is to be learned, and this must be the constant frame of mind of the man who is to succeed under scientific management. He must size up his own shortcomings and regard with sympathy those whose opportunities have been limited, and must have respect for the opinions and knowledge of others, even in the case of the humblest worker.

MEASURE OF SUCCESS.

Of course there are various degrees of success under scientific management. There is, for example, the degree of success achieved by Mr. Taylor and the men such as Mr. Carl G. Barth and Mr. H. L. Gantt who have been closely associated with him in his work. This is the type of success for which the man making the application of scientific management to various industries, seeks.

On the other hand, we have the success of those working in various capacities in the plants where scientific management is being practised, and who owe their success to its influence and the opportunities that it has brought out. A few cases of this sort that have come under the writer's observation may be interesting.

During the past month two men, both of whom started in the same shop—run under scientific management—as machinists, secured positions paying them \$50.00 per week, whereas a few years before they had earned but machinists' pay. These men had been promoted successively from workmen to functional foremen in the shop, and then to the planning department. The opportunities that came to them were the direct result of their training and development under scientific management.

Under scientific management the ability and worth of each man is brought out and recognized, whereas, under the old type of management, "bluff" frequently masquerades, undetected, as the real thing.

A few years ago a concern employing about three hundred people started to install a system of scientific management, and at that time there was employed, in charge of their shipping department, a man who had not attracted any especial attention except as an efficient shipping clerk, in which position his employer would probably have kept him on account of his handling his job well. This department showed up so favorably in comparison with others in the plant, that the consulting engineer directing the development of the new system persuaded the management to place this man in active

charge of certain features of the work, gradually increasing his scope, until finally, when the new system had been fully developed, the management realized that he was the *real* superintendent of the plant, and made him so in name as well as in fact. They had formerly had a superintendent in name only. Incidentally the old superintendent was not injured at all, having assumed during the period of development duties for which he had a natural inclination and for which he was better fitted.

It is not at all uncommon for laborers to become mechanics in plants run under scientific management, nor for the mechanics whom these men succeed, to become functional foremen.

One of the most interesting cases that has come under the writer's observation is that of a laborer who became first a drill press hand, then an all round machine hand, and finally a gang boss. The surprising feature in this case is that when this man first came under scientific management he could scarcely write—could not add $1\frac{1}{4}$ " to $15/16$ ".

These are only a few of a vast number of cases that could be cited, but they serve to show that scientific management is not only a good thing for the employer but for the employee as well.

THE PLACE OF THE COLLEGE IN COLLECTING AND CONSERVING THE DATA OF SCIENTIFIC MANAGEMENT.

BY WILFRED LEWIS,

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By scientific management is understood that type of management which is made to rest upon certain well-defined principles, in the application of which the highest efficiency in human labor is attainable. Mr. Taylor has laid down four fundamental principles of management as follows:

The development of a true science.

The scientific selection of the workman.

His scientific education and development.

Intimate friendly relations between the management and the men.

These principles have been expanded by other writers into many more, but in their application to any given line of work, the development of the science leads to vast accumulations of data which must be classified and arranged to be available for immediate use when needed, and the question suggested by my subject is: In what way can the college be made to collect and conserve the data of scientific management?

Hitherto these data have been accumulated at enormous expense, and their possession in the hands of different individuals or companies has meant practically the doing of the same work with slight variations again and again, simply because there has been no common depository of the data obtained. If a true science in management is really attainable, there must be a common pool into which the rivulets of information may flow, and out of which broad streams of knowledge can be drawn. The mere accumulation of data without intelligent classification and arrangement counts for little,

and this fact was borne in upon me very forcibly when, after great diligence in the accumulation of certain records, it became more expedient to make new ones than to attempt to find what was wanted in such a heterogeneous mass of details.

To a certain extent the scientific selection of the workman can be studied in our colleges, and, by introspection, students can obtain very helpful suggestions as to the career best suited to their abilities; but the scientific education and development of the workman, and the intimate friendly relations between the management and the men, when applied to teachers as managers and to students as workmen, takes on an unusual significance which may well arrest the attention of thinking men.

In modern industry, to which these principles are generally applied, the product is some material thing, the output of which is to be increased for the benefit of the labor employed, the management which directs it, and the public which consumes it; but in the college, the product is the workman himself, a living force fired with the energy of youth and full of promise to himself and all the world beside. The molding of this material for the market which awaits it, or the development of young men fitted for the battle of life, is surely an industry of preëminent importance, and it can hardly be doubted that the place of the college as an institution for collecting and conserving the talents of the rising generation for the best uses of the world depends more upon the scientific management it displays than upon anything else.

I am not sure that Mr. Taylor had in mind the college as a factory for the development of men when he framed his four great underlying principles of management, but he has always contended that there were no exceptions to their application, and I am inclined to think the up-to-date college must not only be alive to the importance of scientific management, but it must also absorb and disseminate the principles upon which its own efficiency and that of its alumni can be built up and maintained.

Scientific management has hitherto been considered chiefly

as a means for increasing the products of labor in industrial operations, and as such it is known to include the wage worker, the employer, and the consumer, in its benefits. If "he who maketh two blades of grass to grow where but one grew before" is a public benefactor, what can be said of him who lights the way for every worker to vastly increase his output and so raises the standard of living throughout the civilized world?

It matters not whether the principles enunciated are new or old if they are made to bear fruit as living forces, and although scientific management is a new term for the general development of all industry, it is frankly admitted by its chief exponent to have been well established for centuries in certain limited fields, and the following extract from the "Meditations of Marcus Aurelius" shows that he was alive to the wastefulness of misdirected effort nearly eighteen hundred years ago.

"They will say commonly, meddle not with many things, if thou wilt live cheerfully. Certainly there is nothing better than for a man to confine himself to necessary actions; to such and so many only, as reason in a creature that knows itself born for society, will command and enjoin. This will not only procure that cheerfulness, which from the goodness, but that also, which from the paucity of actions doth usually proceed. For since it is so, that most of these things, which we either speak or do, are unnecessary; if a man shall cut them off, it must needs follow that he shall thereby gain much leisure, and save much trouble, and therefore at every action a man must privately by way of admonition suggest unto himself, What? May not this that I now go about, be of the number of unnecessary actions? Neither must he use himself to cut off actions only, but thoughts and imagination also that are unnecessary; for so will unnecessary consequent actions the better be prevented and cut off."

But it remained for Mr. Taylor to prepare the way for the accurate determination of a fair day's work by the scientific analysis of the elementary operations and the time required in detail. With these data properly classified and arranged, it is now possible to determine the time required on work

never done before, and when the elementary operations in all lines of industry shall have been so analyzed, classified and arranged, it will be possible to determine the time required for the performance of manual labor under any given condition, and even mental effort to a certain extent can be so formulated. All labor must be resolved by analysis into its elementary units, and these units may then be combined for any desired result. The combinations to a given end may also vary, and the result will depend upon the skill of the expert who prepares the instructions which he must know to be practicable. These instructions are not unlike the laboratory instructions given to college students when they are expected to do certain things in a very definite and exact way, and very often in a certain limited time, and it may be said that the laboratory method is the method of scientific management in the progressive workshops of to-day. It typifies the art of learning by doing, in a very definite clear-cut way. It does not tolerate the initiative of the unskilled, but it gives more freedom to those better qualified to plan and direct. Some of the data of scientific management were therefore collected and conserved by our colleges long before the term itself was coined, and if a department were formed for teaching the science of management, it might become the reservoir into which the working data of all industries might be poured for analysis and redistribution in a more helpful form. Such a department would have an important influence upon the study of political economy and trade unionism, and it might help labor to see its real interest in production rather than in the highest possible wages for the least amount of work. It should be apparent to the dullest intellect that the rewards of labor can not exceed the products of labor, that the producers of the world are its principal consumers, that high wages for a low product increases the cost of living, and that a large product adds to the general welfare of the community regardless of wages, which can not rise above their source as measured in the actual return of the same labor applied to mining the standard of value, gold.

All this should be apparent but it is not, because the struggle still goes on to get more than is to be had out of everything, and by innumerable strikes and lock-outs, the products available for distribution are continually depreciated and reduced, to the irreparable injury of common labor, which suffers most from its own blind folly. In natural rights all men are equal, and it should be the aim of a beneficent government to insure equal opportunities to all. But in ability to embrace opportunities men will always differ, and compensation must be apportioned to results, if the highest efficiency is to be maintained and the largest product realized. The welfare of common labor depends, therefore, upon the welfare of skilled men who are not content with the same reward and naturally forge ahead.

Those who cannot direct or control must follow the leader or come to grief, and in taking their proper places in the world of industry they contribute in the fullest degree to their own happiness and that of the community in which they live. The law of supply and demand, freely exercised and applied to individuals, can be safely trusted to distribute the rewards of labor more justly and more advantageously to all men than any of the Utopian schemes which cut out incentive and endeavor to reduce the leaders of men to the ranks, because without incentive, the efforts of able men will be relaxed, and civilization will surely decline. So, in the mining of gold, this industry will not continue unless the product is at least equal to the outlay in salaries, wages, and fixed charges, and what common labor realizes in this industry can not be exceeded in any other industry without stopping or retarding the mining of gold upon which the maintenance of high wages depends. The matter of wages is therefore under automatic control, and since it does not affect the welfare of common labor so much as the total output in which labor participates, the main interest of labor clearly lies in the cause of efficiency. But how long will it be before this is recognized by the rank and file, and have we not in the philosophy of scientific management another field for the activities of college men? Efficiency

energy suffers for want of expounders, and a vast amount of energy is misdirected by unworthy leaders to mischievous ends. When properly understood and applied there is no conflict between capital and labor under scientific management, and capital is recognized as a factor equal in importance to labor itself, without which the condition of labor would indeed be discouraging. On the other hand, the concentration of fabulous wealth in a few hands, when heralded as it is in the newspapers and flaunted in the eyes of the desperately poor, cannot fail to cause discontent with mutterings of resentment and threats of violence and revolution. And while it is true that prosperity depends upon the energy born of ambition, the time will surely come when the conditions which permit such monstrous accumulations will no longer exist, and by the operation of beneficent laws, predatory wealth will be automatically returned to the community from which it was drawn. This can be done in such a way as to impose no obstacle to the realization of any reasonable ambition, and yet to make the acquisition of unlimited wealth attended by increasing difficulties. The data of scientific management would then be applied to the functions of government, as well as to ways and means for the accumulation and distribution of wealth, and there is really no limit to their fruitful possibilities.

I conceive it to be the function of colleges to collect and conserve the data of the sciences which they undertake to teach, and if scientific management is to be one of them, the data upon which it rests should be included.

In my own business, these data consist, roughly speaking, of certain elements which have been arranged in the form of a chart beginning with the charges for general expense divided into auxiliary, business, and manufacturing, followed by classifications for stores, worked materials, tools, machine tools, and materials. These classifications are subdivided and their subdivisions are again and again divided until we finally arrive at our slide rules for machine time and tabulated records for the determination of handling time. The former

apply especially to the particular tools and machines in actual use, and the latter to information more general in character which would be applicable to machine shops anywhere. It may be impracticable to collect and conserve for general use the data for slide rules or the slide rules themselves designed especially for certain machines. This might be done by the machine tool builders, and the results obtained might or might not be their best selling arguments. The handling time, however, is of more general application, and some clearing house should be provided for its reception and distribution to avoid the expense consequent upon the repetition of this work by independent investigators.

I had thought at one time of the college as the natural depository and distributor of this information, and for this reason I believe my subject was assigned, but we now have engineering societies, some devoted in part to scientific management, others to it exclusively, and this Society for the Promotion of Engineering Education, any one of which might act as custodian for the data of scientific management, and with all these avenues open to those interested in the results, it seems to me that the subject belongs more particularly to the Society to Promote the Science of Management than to any other, and that the place of the college is to participate in the results and lend itself as far as possible to the development of a true science from the data obtained. Its help is also needed in the art of teaching, for under scientific management every plant of whatever description becomes in effect a trade school where unskilled labor is trained and directed to a broader and better sphere of usefulness. The acquisition of knowledge is one thing, and the art of imparting it to others is necessarily in the hands of men who have never been trained as teachers. College methods could therefore be studied to advantage by scientific managers, and the mutual interchange of ideas and experiences between managers and teachers could hardly fail to be of great benefit to both.

AN AUXILIARY TO COLLEGES IN THE TRAINING OF SCIENTIFIC MANAGERS.

BY ROBERT THURSTON KENT,

Editor of Industrial Engineering, New York.

The writer has always had a high opinion of the plan inaugurated by Dean Herman Schneider at the University of Cincinnati for the training of engineers, that is, the spending of a portion of the college course—which is five years in length—in the shops of Cincinnati or nearby towns, during which period in the shops the students work side by side with the regular workmen, receiving instruction and training in shop methods which it would be impossible to give them in the college shop. Although the length of the course seems excessive, the plan is an admirable one in many respects for training engineers who are to become machine shop superintendents, managers, or to hold positions of similar character in other manufacturing lines. Without doubt, the same idea could be successfully applied to other lines of engineering work, such as the various phases of civil engineering, electrical engineering, power plant practice, heating and ventilating or any one of the many specialties in which the mechanical engineer finds occupation.

While scientific management is comparatively new, yet, in a number of industries in this country its principles have been applied with uniform success. These shops, in the writer's opinion, will form the best auxiliaries to the colleges in the training of scientific managers, operating with respect to scientific management courses in the colleges, exactly as do the shops of Cincinnati to the engineering course in the University of Cincinnati. It is not necessary for the purposes of training an engineer in the principles of scientific management that he study the operation of these principles in a machine shop. The principles underlying scientific management are

the same in every industry, and the student in a management course can study their operation fully as well in a textile mill or a printing establishment, as in a machine shop. It may be that he can study them even better, for in many industries there is not the complexity of operations that obtains in machine work, which might appear to befog the clear discernment of the underlying principles.

The most powerful auxiliary to the college in the training of scientific managers, therefore, is the shop in some line of industry which is operated according to the principles laid down by Dr. Taylor. It is not to be expected that a student should become a finished textile worker, printer or machinist should he use one of these industries as an auxiliary to a management course, but he can learn in the most thorough manner in any of these industries, the principles of routing, of scheduling, of planning, of time-keeping, store-keeping, and he also can learn by acting under the instructions of one of these officials, the functions of the speed boss, the gang boss, the inspector and the disciplinarian. In the planning department, he can act, always under supervision if necessary, as instruction card man, time and cost clerk, route clerk, etc.

The plan the writer advocates in the training by colleges of men to fill positions under scientific management, is that each college having such a course arrange with one or more industries in its vicinity to have its students spend a part of their time in that industry, much along the lines that the students in the University of Cincinnati spend their time in the shops of that city. The course should be arranged so that the students will spend several consecutive days or weeks each month in the shop, performing the functions of one or more of the planning department officials or of the functional foremen out in the shop.

The writer is of the firm belief that engineering education is of comparatively little commercial value until it is supplemented by practical training in commercial work, whether that work be shop practice, construction work or any other line which the student elects to follow subsequent to the com-

pletion of his college course. This idea applies just as much to engineering work which specializes in management as it does to engineering which specializes in machine design, power-plant practice or any other line of engineering. The student who has studied the theory of management from books and depends upon this theory alone is apt to encounter many pitfalls in his attempt to apply what he has learned. The big problems in management are not those of following a certain fixed set of forms or rules based on the fundamental principles enunciated by Dr. Taylor. The vital problem in management is that which involves a human element. It is psychological and until the would-be manager actually comes in contact with the workmen and comes to understand the attitude of the workmen toward all in authority above him and toward his work, he will inevitably fail in his attempt to be a successful manager. This knowledge cannot be gained in the class-room. It must be gained by actual physical contact with the workmen. It is, therefore, the writer's opinion that no college giving a course in scientific management can have a better auxiliary than a close working connection with some industry that is operating under the principles of scientific management.

TEACHING SCIENTIFIC MANAGEMENT IN ENGINEERING SCHOOLS.

BY ROBERT B. WOLF,

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It is not my purpose to go into an elaborate discussion of the principles of scientific management, but simply to give briefly my reasons for believing that it should be taught in our engineering schools. In this day of keen competition no manufacturing establishment can be conducted successfully by the old "rule of thumb" methods. This is especially true in that class of manufacturing which has been established for some time and where competition and increased cost of raw materials have reduced the margin of profit. There are quite a number of establishments, such as machine shops, foundries, etc., where the principles of scientific management have been worked out to a very fine point by Dr. Taylor and others. Any one starting out in this line of work need not be put to the trouble and expense of conducting a long series of costly experiments to determine such a question, for instance, as the proper method of cutting metals. A thorough course outlining these principles can well be added to the curriculum of our engineering schools. This course should describe in detail the methods used in up-to-date machine shops, going into the subject of "time study" work, store system, and general accounting, which will undoubtedly save many a young engineer from spending his time going over the ground already covered by others. He could then devote his energies to extending the field still further.

In some industries the principles of scientific management have been so well worked out that it is hardly any longer a question as to what are the best methods to pursue. If the engineering schools will take up this subject, it will enable the students to profit by the experiences of others, thereby

tending towards ultimate economy in manufacturing methods. The very excellent treatise on the art of cutting metals, by Dr. Taylor, might well be used as a text-book, even though the student does not intend to follow machine-shop work. A careful study of this book, so that the principles involved are recognized, will assist materially in pointing out the general methods that should be followed in pursuing any line of investigation. These identical principles have been adopted, for instance, in the cooking or boiling of pulp in sulphite digesters.

A course describing the methods in use in making motion-study might well be added, as this is an important part of scientific management. As an illustration of this, there is one large pulp manufacturing concern that was able to save over \$200 per day in freight paid to the railroad companies, by a careful motion-study to eliminate lost time in the operation of its hydraulic press equipment for pressing moisture out of the pulp. There should also be included a course describing the various methods of rewarding men for their increased efficiency. This must be gone into very carefully in order to point out the danger of attempting any kind of piece work or bonus system, without scientifically determining in advance the best methods to follow. Mistakes made by imitators of scientific management might have been avoided if a more thorough knowledge on these subjects had been available. The methods for rewarding foremen and department heads, so that they will be stimulated to their best efforts, should also be studied, as well as those used to determine the departmental efficiencies.

Another important subject is the use of graphical methods for analyzing the results of investigation and keeping track of operating conditions. Considering the extreme simplicity of this method and the impossibility of obtaining intelligent results in any other way, it surely seems that this subject should be given a great deal more attention in our technical schools. There is nothing new, of course, about graphics, but its general application to business is new and should be studied.

All of this, of course, involves experience and it is highly desirable that the subjects previously referred to in this paper be taught by men who have had experience in putting these principles into operation. In my judgment it would be improper and might be productive of harm rather than good if college instructors simply took up the subject by text-book and attempted to teach it. The true principles of scientific management cannot be comprehended in this way alone, as the practicable conditions can only be learned by actual contact with the work and have a great bearing on the final conclusions. If this subject must be taken up by the regular instructors in the engineering schools, they should be given permission and time to go into the manufacturing establishments now operating under this system, to become thoroughly familiar with it. After having done this they will be in a much better position to teach the subject in an authoritative and interesting way.

After having acquired a knowledge of the mechanism of scientific management the student should also be taught the general philosophy of the subject and it would be well to include in this connection a course in biology and practical psychology, for the reason that the true test of scientific management is that it improves and elevates the mental and physical condition of the workman. A wrong impression has been given by some of the opponents of scientific management, who claim that it tends to make automatons of men. If this has been done in any of the industries it is because the true principle has been departed from and for this reason, if for no other, the treating of the subject in a comprehensive way in our engineering schools would be a great advantage, and would tend to prevent mistakes of this character.

One other thing that scientific management has pointed out very clearly is that the physical condition of the men should be considered to its fullest extent and that the men who are overworked and working in unhygienic surroundings are in the very nature of things bound to be more or less inefficient. A general treatment, therefore, of hygienic law is necessary

as well as a course in physiology and personal hygiene. A great many men are inefficient largely because they lack a knowledge of how to take care of themselves, so that it is part of the system of scientific management to conduct a campaign of education along these lines. This, of course, cannot be done intelligently unless the men at the head of the organization realize to the fullest extent what this means.

It seems to me, in view of the fact that our engineering schools are turning out the men who become the heads of our large manufacturing concerns, that it is of the utmost importance that they send out their students thoroughly equipped with a knowledge of the principles of scientific management and in this connection I believe that the course should include visits by the students to establishments now operating under this system. This would not only tend to make the course more interesting, but would fix in a more permanent way the things learned from the text-books. In conclusion, I can say that the large progressive manufacturers of the country would welcome the thought of our engineering schools taking up this subject.

THE TEACHING OF SCIENTIFIC MANAGEMENT IN ENGINEERING SCHOOLS.

BY HOLLIS GODFREY,

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Two problems confronted the writer of this paper when he began his work:

First, to take the engineering school as it commonly exists today and use its equipment effectively in the creation of a practicable course for men who desire to follow the profession of industrial or management engineers.

Second, to take the student as he is and to equip him well for his work, giving him studies which will be of real value and which he cannot as well acquire afterwards in the shop.

It is merely good management to use all the facilities which now exist in the engineering schools. Their regular courses are, in my belief, admirably adapted to their purposes and admirably conducted as a general thing. I propose to use those courses in the training of the industrial engineers so far as possible. There is room in scientific management for the man trained in every type of engineering. I propose that the student of the science of management shall take three years out of four in some one of the regular courses in engineering, devoting one year's work, made up of half the work of the junior year and half the work of the senior year, to the direct courses in scientific management and to their allied courses. The allied required courses are often given in engineering schools, and are almost always given in the colleges of arts, which commonly exist combined with engineering schools. The direct courses advised here are given in the form proposed, so far as I know, in no engineering school, and amount to four half courses. The progress of the work, as will be noted later, requires that the work in scientific management shall be begun in the junior year. I believe that the plan outlined here is practicable and will enable an engineering

school to make the best use of its present equipment in the training of the industrial engineer. I believe that all the content of these courses can be much better acquired in the engineering school than in the shop after graduation.

The American undergraduate today, both in the college and in the technical school, appears to me marked by a most profound ignorance of industrial conditions, both in general and in detail. Whether that condition comes from modern city life or not it is not the province of this paper to discuss. All the evidence at my disposal goes to show that it exists. I do not believe that any lecture course can conquer that ignorance, for I do not believe that the average student has any basic knowledge, apperceptive basis, if you will, on which to build the theory of the science of management. For that reason I should prefer to make it a prerequisite to the junior and senior courses in industrial engineering that the student electing these courses should be required to spend the sophomore and junior vacations in the shop. I should assign more hours a week to shop or laboratory work than to lecture and recitation, but not more laboratory periods.

It is partly because of the undergraduate's ignorance of industrial conditions and partly because the opportunities of the shop to give training in the science of management are limited, that I state my firm belief that a man trained for four years by the plan outlined here will be far better equipped to handle industrial problems than a man graduating from one of the regular courses who attempts to obtain his knowledge of the science of management in the shop. I had believed that the basic theory of the technical school, namely, that the student could advance far more rapidly in the school than in the shop, had been settled long since. It is on that basic educational theory that I propose the training of the industrial engineer in the engineering school, yet to my surprise I find some engineers proposing to make shop training alone serve the special needs of the industrial engineer, thus proposing a theory which is quite outworn for the other branches of engineering. Shop and school are too firmly welded to-day to allow either to stand alone.

As regards the question of whether it might not prove wise to give one or two extra years to the training of the industrial engineer, I have expressly excluded this proposition from my paper, as I have limited myself to the discussion of the engineering school as it is. I, therefore, took the four year course as my basis.

With the assumption that the work of the student of scientific management during the first two years will be the same as that of the student in one of the existing engineering courses and with the assumption that the student has spent his sophomore vacation in the shop, suppose we start the student selecting scientific management, at the beginning of his junior year and discuss the direct and allied courses in scientific management which he will take in the two years before graduation. That brings us directly to the question of what powers and what information should be given the student of this subject. As regards the powers, the best way that I know to obtain some statement of those is to turn to the powers possessed by successful industrial engineers of my acquaintance.

According to my analysis the essential powers possessed by those successful engineers are the following:

First, the power of using the work done by other men. That power saves a man from repeating uselessly work done before, saves him from repeating the mistakes of others and enables him to build on the foundation of the best work already done.

Second, the power of perspective, of adjustment to environment, of seeing the proper relation which a process bears to the other processes in a plant, or that a plant bears to its industry as a whole.

Third, the power of research, of so collecting, correlating and translating masses of facts as to obtain their meaning.

Fourth, the power of the making of designs and the carrying out of construction in the basis of the facts obtained by research.

Fifth, the power of expression, gained largely through the study of English, which makes both research and construc-

tion so intelligible and useful that no time is wasted through unintelligibility.

After powers comes information or perhaps it would be better to say that powers and information combined bring us to courses allied and direct. The first allied course that I should require of the student is economics. The industrial engineer must work with both men and machines. It is his task to produce, to bring order out of industrial disorder, and the history of economic advance, as well as the advances of present day economic research, must be placed before him if he is not to waste time in repeating needlessly the economic mistakes of the past. The industrial engineer must have the light of economics upon his work. He must be able to use intelligently the new work in economics, but it must never be forgotten that he is personally a scientist, not an economist; that, to use Ely's phrase, he is to deal mainly with natural rather than descriptive science.

So much for the necessity of the work in economics to which I have assigned a course and a half. Two full years have been assigned to those courses which aid the industrial engineer to understand the physical and mental condition of the worker, one year of physiology, hygiene and sanitation and one year of psychology, including experimental psychology. I believe that no single factor is to take more commanding place in the development of the next years in scientific management than the work to prevent the evil effects of the old type of management, of speeding up, of rush work and of disagreeable and dangerous processes. The effect of industry on the human frame and the human mind, the replacing of false theory with scientifically determined facts as regards the physical and mental condition of the worker, will be a part of the work of every industrial engineer. The graduate in this course must not only have acquaintance with the present state of knowledge in the subjects specified, he must be able to use the advances of knowledge obtained by the sanitarian and the psychologist.

Of the necessity for a half course in the theory and practice

of accounting it is perhaps merely necessary to speak of the necessity for the industrial engineer to have a thorough knowledge of costs and of their relation to the books of the regular accounting system. The industrial engineer must, in the last analysis, have his eye constantly upon costs, for in no profession is it more necessary not to have the work cost more than it is worth. Summarizing the allied courses we find that the list is as follows: One year and a half of economics; one year of physiology, hygiene and sanitation; one year of psychology including experimental psychology; one half year of the theory and practise of accounting. I assume that equal amounts of lecture and recitation time are allotted to each full course, so that Scientific Management 1 A and 1 B for example, would use the same number of lecture and recitation hours as Economics 1. The laboratory hours required for the Scientific Management courses would be additional to this.

As regards the content of the allied courses proposed here, it seems to me that the conditions existent in different institutions vary so greatly as to make it impossible at present to advise specifically the ground that these courses should cover. In each case the relations between the direct and allied courses must be determined by the cooperation of the men in charge of the work, and the content of the allied courses will be affected by those relations. I advise specifically here as regards the content of the courses in Scientific Management, but I feel that the welding of these courses with those now existent is an individual problem which each institution should solve for itself.

Turning directly from the allied courses to the direct courses in the science of management, we find that these courses divide naturally into four half courses. Scientific Management 1 A, the first, is intended to give the student a general view of industry and of the principles of scientific management. Scientific Management 1 B considers the problems presented in the planning of work and of all operations preceding the actual shop operations. It lays especial stress

upon the lesson to be taught throughout, namely, that scientific management is a science to be solved by scientific methods. Scientific Management 2 A takes up the problems of work in the shop with especial reference to the workman and his machine. Scientific Management 2 B considers the results of the work done in 1 A, 1 B and 2 A, and takes up problems of costs, of purchasing and of sales and especially considers the scientific determination of the policy of a business.

Each of these courses is aimed to meet certain definite needs or to furnish certain necessary information. Summarizing these needs in the case of Scientific Management 1 A we may say that this course is designed:

1. To meet the ignorance of the student concerning industry and to give him some understanding of the flow of work. To give him some understanding of the principles of the science of management and of general methods of the scientific attack of industrial problems.

2. To make him realize the main common factors in industry.

3. To make him realize the main differing factors which make every plant in every industry a new problem.

4. To show him the methods of statistical research by which laws and principles are determined.

5. To train him in observation, to enable him to separate process from process and function from function.

6. To give him actual examples of the application of other sciences to the problems of management.

To accomplish the purposes just laid down I propose that the student in this course shall make an examination of four industries, taking one representative plant from each industry, and that he shall examine every step in the flow of work from the first inquiry of the customer to the final settlement of the account, examining these steps broadly without going into their details. To put it another way I propose that the student in this course shall study the broad divisions of four plants in actual operation, leaving the study of the subdivisions to follow in the next three courses. Together with this

examination of actual conditions I propose that the student shall examine those factors common to all the industries and the factors which are different in each industry.

Few things are more important in the very beginning of the student's work than to have him see that a system built for a given plant and working admirably for that plant will not apply in another plant as it stands, for the simple reason that the different factors in the second plant require study before the systems involving these new factors can be designed or constructed. It is most essential at the very start to make the student realize that he must rely on science and not on a previously obtained mechanism to solve the problems of each new case, that he must solve his problems by the use of the principles of scientific management and not by the application of any ironclad system. That lesson once learned opens the road to the proper study of the principles of the science of management and of the methods used by that science. These methods are, of course, practically those used by every other science, yet one part of them, the methods of statistical research, the proper translation of masses of statistics, the obtaining of the significant figures, if you will, needs more emphasis in the case of the student of industrial engineering than would normally be required of students in most of the other engineering courses. Our knowledge of methods of statistical research is increasing daily. They offer too valuable a tool for the industrial engineer to be omitted from a course in scientific management.

In this connection it is important for the student to learn that the mere accumulation and even the correlation of data may have no value and may be an extremely expensive habit, provided judgment is not used in the selection of the data to be studied and provided the data, once assembled and correlated, is not rightly translated into usable form. Few things need the control of common sense more than statistical research. Few things are more valuable, once that control is exercised. Work in graphical analysis should prove of assistance here.

It is extremely necessary in a course such as is here out-

lined that the student should be required to test and retest his knowledge. No student should be allowed to complete this course without handing in a report showing a careful study of the main processes in some plant in actual operation, preferably a plant engaged in some industry not among the four industries chosen for the course.

Having gained his perspective in the first course in scientific management the student may begin the study of detail in the second course in which, as has already been said, it seems advisable to consider the planning and preparation processes which occur previous to the passage of the work into the shop. This course involves the detailed study of a group of the main factors involved in management, routing, stores, etc., determining the subdivisions of these factors for individual cases but excluding direct machine operations. Methods of collecting all available data concerning these factors of industry, the making of a science out of the operations of an industry through the collection, correlating and expression in useful form of all data concerning an operation, should be shown here with especial reference to the working out of the first principle of scientific management as given by Dr. Taylor. Mechanisms derived from scientific study and already in use in different places should be considered and basic likenesses in these mechanisms discussed. Differences, existing in different industries, should be considered and it should be made plain that these mechanisms, being based on scientific study of principles, will differ outwardly in different cases but will be basically the same.

The fact that men and machines, and not machines alone, are studied in the science of management must be brought out here in connection with physiology, hygiene and sanitation. The effect of heat, light and air on the workman, the problems of fatigue and the deleterious effect of the rush work of the old type of management should be especially considered here.

The student in this course should not go back of the point where the orders are transmitted from the sales department

into the factory, but his study of the preliminary processes should begin at this point, pass through the study of design, of preparation of material or stores, through study of the principles of stores, through routing, order of work and the control of work going through the shop, and should include some symbolization and some studies of the general articulation and functionalization of the planning department. Study of the problems of tools, of time study and of instruction cards, although technically, perhaps, included in this division of the subject, should be left until the following course.

When the student has completed the course outlined above he should have a fair knowledge of the best practice of industrial engineering in its relation to the planning of work. He should have a fair conception of the methods of attack by which industrial difficulties have been solved and the way in which they may be solved by the application of the science of management. He should himself have gained some power in the solution of practical problems and he should be required at the end of this course to prove his ability by the actual solution of an actual problem of the planning room.

Scientific Management 2 A purposes to take up the problem of the passage of work through the shop from the beginning of the first machine or hand process applied to the raw material to the delivery of the finished article to stores or to the shipping room. It involves a study of machine and hand processes but this is but a part of its work. It is in this course that the student first meets the great problem of the task, of the substitution of the justice of science for the guesswork of man as a basis for the coöperation of employer and employee, and meets the problems of education that are involved in the theory of functional foremanship.

We may outline briefly the subject matter of the course as follows:

1. Study of the task with a view to the elimination of all disagreeable and dangerous elements.
2. Study of the task with a view to determining the duties of the management in obtaining the right task.

3. Study of the task with a view to machine improvements.
(These studies should be done in the shops of the school.)

4. Study of the education of the workman.

5. Study of functionalization in the shop.

6. Proper methods of instruction card writing.

7. Proper methods of record.

The following subjects should also be considered here:

8. The selection of the workman.

9. The study of physiological and psychological factors involved in certain given cases.

The student who gains what he should from the course in Scientific Management 2 A should gain far more than the technique of time study. He should make appreciable gains in his power of observation and of analysis. He should gain the conception that time study, far from being a weapon to wrongly speed up a worker, furnishes a means of removing the disagreeable, inefficient and dangerous elements of a worker's task. He should gain facility of expression in the practice of making out instruction cards, improve his power of choice in the selection of tools for tool lists, and gain a considerable appreciation of the best methods in vogue to-day for the increase of the efficiency of men and machines.

No part of his work should give the student more understanding of the problem of obtaining the workman's coöperation than his study, towards the end of this course, of the problems of the scientific selection and development of the workman as laid down in the second and third of Dr. Taylor's principles of scientific management. The year's work in physiology, hygiene and sanitation which has preceded this course, the work in psychology which goes on with it, should be of great aid to the student in his effort to comprehend these most important principles.

At the end of this course, the student should present a report of a rather comprehensive nature involving the determination and expression of a task. This report should involve not only time studies, but all the expression of the task as shown in the writing of instruction cards, tool lists, work of

functional foremen, etc. The work in English should show its value here.

Scientific Management 2B, the final course, considers the results and records of planning and of work in the shop. It should consider the effect upon design of the records made in both of the previous courses and especially the effect upon the policy of the firm of the weak and strong points brought out by the scientific study of the various problems involved. The latter part of the course should be given up to a general review of the whole subject and should give especial consideration to the fourth of Dr. Taylor's principles of scientific management, the new division of the total burden between management and operative, as shown in all the courses.

Summarizing the general subject matter of this course, we may say that this fourth section should concern itself, first, with the proper recording of the work done in respect to time and to costs; second, with methods of wage and bonus determination; third, with methods of inventory taking and purchasing curves; fourth, with methods of design in scientific management; fifth, with a general review. Then, as determining future policy, should come the study of sales curves and cost curves, those great aids in determining what classes of business really pay.

The wide-reaching possibilities of using the investigations of scientific management in determining the policy of a business, in respect to design, to classes of product, to choice of customers, and to determining the field of sales has received as yet but little outside notice. Of the two functions of cost, one, the use of costs in determining prices, has received a fair share of attention. The other, the use of costs in determining the most profitable classes of business, receives to-day nothing like the attention that it merits. The work in costs should not only teach the student methods of cost distribution which will distribute every penny expended in a given time upon the product manufactured in that time. It should teach him also to use costs as a constant check upon the progress of his own work and as a guide to the future direction of a business.

Sales curves added to cost curves throw still more light upon the problems of the most favorable fields to attack and the classes of goods which seem best suited to both the production possibilities of the factory and the requirements of the customers. In a great number of the factories of the United States to-day the sales and the manufacturing departments live in a state of warfare. Service is pitted constantly against production. It is peculiarly the province of the industrial engineer to determine by study the actual basis on which the most profitable service and production can be given and to bring the sales department and the factory into harmony.

The problems of the maximum and minimum quantities to be carried in stores, requires careful study if a plant is to avoid the two extremes of being out of material or of locking up too much money in stores. Both extremes are dangerous and both should be avoided by scientific study and not by guesswork. Work of this sort begun earlier may be amplified in course 2 B.

The application of these investigations to design, governed largely by the charted studies of time and costs, has produced remarkable results both in the adaptation of design to the needs of the customer and consumer, and in the cutting down of the costs of the article. The final course, Course 2 B, is the place for the discussion of these points.

At the end of the course the student should make a report embodying actual reports of time and cost, of sales and purchasing curves for a given plant.

As regards the methods of instruction,—lecture, recitation and laboratory are all mingled in about the usual proportions. The laboratory work must largely be done in allied friendly plants, but the present day interest of manufacturers in technical education should make this easily possible. No task setting should, however, be done elsewhere than in the shops of the school. That is too delicate a matter for student hands and involves too many possible difficulties when done by others than experts.

I left teaching a considerable time ago when I took up

the study and practice of the science of management, but I believe I have not lost any of my interest in effective teaching or any of my beliefs in education. This paper is the outcome of my interests and beliefs in education and in scientific management. And I believe in scientific management because in the period during which it has been my good fortune to have been associated with Frederick Winslow Taylor, I have never found any industrial problem which the science of management would not solve. I have seen with my own eyes marked savings in money, marked advances in service and production, marked improvement in the condition of the worker. With that personal experience it is perhaps no wonder that I have become an enthusiast on the subject, that I look for its advancement in every way and that the teaching of scientific management should interest me deeply.

I believe that with the training outlined above, properly given by qualified men and properly assimilated by the pupil, the student should reach the end of his course a thorough believer in the science of management, with the desire and ability to use the scientific spirit in the solution of the problems of industry. He should have a mind that is willing to accept and use all that is best of the work of other men, yet he should be constant in the pursuit of knowledge. The industrial engineer will never be a man who "knows his own business" for he knows that no man can measure or limit the advance of science. Free from dogma and from prejudice, blessed with the open mind and with the equipment of modern science the industrial engineer, so trained, should be prepared to do his part in bringing justice and betterment to every worker everywhere in the new industrial day.

Note.—In the preceding paper I recognize that I present the view of one man, aided by friendly criticisms. The development of a course of the kind proposed here must be, in the last analysis, the work of many men. It has been my aim throughout this paper to make definite statements which can be definitely shown to be practicable or impracticable in a given case. Deeply interested in the problem as I am, I shall welcome all constructive criticism.

TEACHING THE PRINCIPLES OF SCIENTIFIC MANAGEMENT.

BY WALTER RAUTENSTRAUCH,

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The records of this society, the transactions of engineering institutes, articles in the public press and the reports of many conferences give evidence of an ever increasing interest in the subject of engineering education in preparation for service in the manufacturing industries. The remarkable results being accomplished by American manufacturers in the production of commodities at lower costs than were obtained in earlier years have awakened the people to the possibilities of accomplishment in all lines of human endeavor through a more accurate knowledge of the factors of cost incident to these activities. Efficiency societies, committees of the national and local engineering organizations and special publications devoted to the Science of Organization, Management and Production are springing into being, for the purpose of spreading far and wide a knowledge of those principles of production which have been so effective in the industries where they have been sanely tried. While many commercial institutions have been put on a more substantial foundation to the benefit of both producer and consumer, and industries overburdened with financial obligations, occasioned by errors in operation and management, have been given a new start, yet some manufacturers and managers of the old school have held themselves aloof from partaking in this new movement because of years of prosperity under the older conditions of manufacture. It is not surprising, therefore, to find the same attitude in some of our universities and colleges where the policies are dictated by professors schooled and experienced in means and methods of instruction which no longer parallel the modern requirements of engineering service, and

whose knowledge of present engineering practice is mainly derived from text-books.

Our successful industries to-day are those which have adapted themselves to the changing economic conditions of the times and are not judging their present condition by the results of past performance. So also will it be found that our engineering schools will progress to the extent to which they keep the subject matter of their courses and methods of instruction abreast with the practice of the profession for which they propose to give preparation and also not to judge their excellence by the records of graduates who have become successful in practical life. Serious attempts are being made not only within the universities but without, to have the courses of instruction in engineering more closely identified with modern conditions of service but the changes proposed lead one to believe that emphasis is not being placed on the most important factors. As it has been found true in the case of the factory that modern improvements are wrought not by *additions* in organization, equipment and accounting but rather by a complete change of policy and ideals even extending to the organic design of buildings and equipment and the occupation of new ground, so also will it be found in the engineering schools that the preparation of young men for engineering service is not much improved by mere addition to the curriculum but there must be complete changes in ideals, methods and means of instruction. Accordingly, therefore, those schools in which the purely technological aspect of engineering problems has for years predominated the courses of instruction, will never effect a successful change when they attempt to retain the old presentation of subject matter and simply add courses in "scientific management" to satisfy the popular demand. No separate course of instruction pretending to deal with the science of organization, management and production, divorced from vital contact with problems of design and performance in which these principles are embodied, will ever be effective when standing alone. Whatever instruction is offered in these lines must always be

paralleled by applications and illustrations in all courses of the curriculum. Universities attempting to teach the "science of management" to non-technical students; bookkeepers and accountants engaging in the business of advising manufacturers in the matter of lowering the cost of productive processes of which they know nothing, only serve to misguide many an earnest youth who seeks to prepare himself for real and substantial service.

No one would dare suggest the revision of legal procedure or scientific management of the courts by one not well versed in the law, nor can it be imagined that the great problems of public health should be attacked by one not thoroughly drilled in the science of medicine, yet our great industrial institutions are continually embarrassed and even persecuted by men wholly incapable of comprehending their problems. The time is not so long ago when the architectural features of a bridge or a factory building together with the maximum limit of appropriation of funds allowed had more influence in the design of such structures than the relation of their income producing capacities to their cost. The technical excellence of the design and perfection and accuracy of workmanship were matters of considerable pride to producers and were not to be degraded through considerations of a mere utilitarian nature. In some quarters this point of view still lingers and is fostered by municipalities and governments requiring of their engineers of public works to judge their expenditures by the limit of appropriation available. But the manufacturing industries compel the engineer to render an entirely different kind of service. Some professors having knowledge of the older form of service, a magnified regard for excellence in technic and a tendency toward the academic, find great difficulty in adapting themselves to the pressing demands of modern times.

No attempt is being made to belittle the worth of a high degree of scientific ability; we cannot have too much of it in our schools. But it is believed that it alone may be far removed from an ability to solve commercial problems. The

most highly skilled artisan may be a very poor man to decide the policies to be followed in manufacturing a line of goods for a given market. So also the most scientific professor, understanding all the laws of thermo-dynamics, may be wholly incapable of selecting the most economic commercial equipment of power machinery for a station to meet a given service condition; or being able to solve the most complicated problems in stress analysis, may not be able to determine the type of bridge which will burden the transportation system with minimum capital charges or perform its service with minimum weight. This feeling on the part of the professor that he possesses a superior sort of knowledge, far above that possessed by the business man is conducive to a wholly inadequate treatment of the subject he professes to teach and is evidence that he does not appreciate the nature of the service for which his students should be prepared. Any course of instruction, no matter how excellent in its treatment of scientific facts and methods of analysis, highly desirable as these may be, is incomplete when it fails to impart to the student a knowledge of the conditions under which this information may become commercially serviceable. Our engineering schools are supposed by employers to have for their aim the preparation of young men for service in our great industrial institutions engaged in the manufacture of commodities such as shoes, hats, typewriters, jewelry, glassware, brick, cement, soaps, cloth, paper, paints, automobiles, locomotives, steel and iron products in endless variety, form and complexity, and the creation of services such as light, heat, power refrigeration, communication, transportation and information. According to the 1910 census the manufacturing industries alone in the United States represent an investment of capital of about 13 billions of dollars and produce an annual output of nearly 20 billions of dollars value, employing 6 million people who directly support through these earnings about 25 millions or nearly one fourth of our population. These manufacturing industries, having such important economic relations to our welfare, are brought into being and sustained through the

labors of the engineer and the capitalist supported by the people investing in industrial securities. That the engineer and the capitalist may successfully coöperate, each must understand the laws which condition the existence and prosperity of the manufacturing industries. As the banker is guided in his investment in industrial securities through his knowledge of their probable earning capacities so the manufacturer or engineer wisely invests in machinery and plant, materials and the labors of men according to his ability to forecast their probable earning value. That the bond is a mortgage on an electric railway, a gas plant or a municipality is merely incidental to the banker, so also that the commodity is steel rails, alarm clocks, collars, or steam machinery is incidental to the manufacturer and engineer.

Because of the knowledge of scientific facts necessary for the engineer to enable him to deal with these commercial problems it was once believed that instruction in these alone was a sufficient preparation for the practice of the profession. Hence this sort of teaching characterized our engineering schools in the early days and still exists in some institutions at the present time. But the more alert minds in our engineering schools, in touch with practical affairs, are aware that this is not sufficient. Thermodynamics most positively indicates the superiority of the gas engine over the steam engine; yet the progress of the gas engine has depended little if at all on this long-known principle but rather on entirely outside practical considerations such as difference in first cost, size, space occupied, repair and maintenance charges, the nature and quantity of labor required for their operation, and the availability of fuel supply in gaseous form. All these conditions and many more enter into the question of true economy and are entirely outside of the consideration of thermodynamic economy. Therefore, any theory of power-generating machinery which fails to include the various factors of cost, including labor as well as capital charges, and their variation with local conditions, is not a complete theory and therefore not a theory to teach engineering stu-

dents. These mathematical laws are very valuable in explaining results attained and preventing attempts at the impossible but not nearly so useful in that prediction of results, which is the prerequisite for design of whatever sort, as many of their professional advocates have for years taught their students to believe. For many years past the average course of study absolutely ignored all those subjects or methods of treating subjects that were not capable of algebraic formulation. The labor and cost questions, although they are at least of equal importance, have been ignored, while the mathematical or purely technological has often been carried to absurd extremes. Those parts of engineering subjects which admit of treatment by the theory of numbers are always beyond doubt absolutely essential. It is not the purpose here to belittle them but rather to place them in their proper position as partially and not by any means wholly preparatory subjects. It is indeed important to teach students to lay out machines, to determine the forces in the mechanism, and to proportion the parts for stiffness and strength but it is equally important that they be taught that a variety of machines might be designed to perform precisely the same service, and that there will result perhaps varying degrees of goodness but certainly great variations in cost not only to build them but to operate them. Unless a machine can be built at a cost sufficiently low to meet the demand it will never get beyond the experimental stage and there is absolutely no use in designing a machine if its cost of production or operation exceeds what can be properly paid. It is certainly important to teach the students how a bar can be turned round or a plate made flat or how every operation necessary to making a machine may be carried out by a mechanic; but it is equally important that he should know their relative costs so that he may avoid the expensive operations or reduce their use to a minimum. He should also be taught that the maximum economy in producing that machine will result when it is made in quantity, and why, and that quantity production will involve changes in design, changes in shop processes because it permits the use

of special instead of standard tools and finally and most important, that quantity production involves many men and that many men require management that each may produce the maximum for his wages, and that such an organization for economic production is subject to laws and principles of far greater consequence than all the thermodynamics that was ever formulated; and yet laws of essentially the same nature as those that control the design of his machine.

The teaching of each subject in the engineering school from this point of view seems to furnish the only means through which an understanding of the foundational factors in the economics of production can be acquired. Any ideal short of this will only serve to further the feeling, all too prevalent even in practice, that the science of production may be considered apart from the very forces which it proposes to control. It is believed therefore that a knowledge of the principles of economic production is a necessary part of every engineer's equipment, be he designer of machines, structures, waterways or public works, employee or employer, in order that he may be able to successfully coöperate with or coördinate the labors of many men, working in many fields but all endeavoring to create a given commodity or render a service to satisfy a real demand.

This ideal has been the end toward which every course of instruction in the department of mechanical engineering at Columbia University has for years past been directed. This course of instruction which was developed under the leadership of Dr. Charles E. Lucke, head of the department, includes courses in principles of organization, management, cost accounting, wage payment methods, economics and business laws as a necessary part but by no means the whole of an adequate treatment of the principles of economic production. The aim of the course is not to train managers but engineers. Should our studies through personal qualifications prove to be adapted to the problems of management, well and good. Limitation of time will not permit a survey of the outlines of all courses of instruction given in this institution, but

it is hoped that the consideration of a few will lead to a clearer exposition of what is believed to be a proper presentation of subject matter. To this end there have been chosen the courses in steam power, elevators and conveyors, shop processes, organization and management, and the factory and power plant work required of the students in the second and third summers respectively.

Steam Power. Three hours and two afternoons.

Relation Between the Cost of Power and Thermal Efficiency of the Plant. Commercial Value of Refinements—Determination of engine and boiler ratings and corresponding efficiencies and probable coal and water consumption for plant on given load curve. Essential relation between processes and dimensions of the steam plant. Steam plant refinements for raising efficiency of part or complete plant and relations between dimensions and effect. Use of unit costs of apparatus in estimating, examination of cost sheets to determine prime unit of cost. Cost of power. Fixed and operating charges, ratio of each individual item to total, and effect of labor and fuel rates, load factor and refinements on the fractional part. Value of refinements of design on basis of capitalized annual saving by comparing the cost of waste and the cost of its elimination, including all charges. Specifications and contracts; standard and special methods and forms for defining purchaser's requirements and builder's proposals, contracts, methods of power plant erection. Designing and erecting office organization and field systems.

The work consists in laying out a simple power plant for assigned units in the drafting room or the detailing of existing general plant drawings, preparation of the bill of materials, estimating the first cost, fixed charges, probable coal, water, labor and supply cost for an assumed load curve and total power cost. The plants so designed or detailed are exchanged by students and redesigned for an increase of 100 per cent. peak and 50 per cent. mean daily load and for the maximum power cost reduction by the use of plant refinements and auxiliaries when it can be shown that additions and alterations will pay. Specifications are written for the alteration and proposals submitted.

Fourth year Mechanical Engineering.

Shop and Factory Work.

Practical Work and Directed Study in the Shops and Drafting Rooms of Representative Manufacturing Establishments with Report—Each student is provided with a printed copy of the things to be studied and reported on in detail, of which the following is a general summary.

Machine Shop. Functional operation, characteristics and powering of machine tools, capacities, layout of shop, size of shafting, belting and motors for independent and group drive. Range of cutting speeds, feeds, depth of cut. Shape and size of tools used. Report on specific observations on time of setting work, time of forming and finishing, number of pieces turned out per hour. Facilities for handling work at the machine. Facilities for producing pieces in quantity. Hand processes for finishing and tools used.

Pattern Shop. Materials of which patterns are made and methods of treating. Machine tools used in the pattern shop, arrangement, capacities, adaptability, handling and storing of material and finished product.

Foundry and Forge, Description of hand and machine tools and appliances used in the foundry and forge. Compositing and treatment of foundry sands. Methods of molding. Time involved. Methods of powering, venting and chilling, cooling and finishing, handling the cupola. Composition of the charges and mixtures, temperatures, pressures, time required to charge, to melt, to pour, cool and clean. Appliances in the forge shop. Operation of power hammers, bull-dozers, shears, heating and annealing furnaces and hand processes of forging. Time involved in production.

Drafting Room. Standards and conventions used. Filing and marking of drawings and recording of patterns. Bills of material—parts to be made—standard parts in stock.

General Management and Organization. Methods of recording time of workmen and their time distribution over different jobs. Paying of men, methods, rates, forms and records used. Drawing of materials used from storeroom and charging to orders.

Prerequisite course is second year shop work.

Elevators and Conveyors. One hour.

Mechanical Handling of Solid Materials by Standard Elevating and Conveying Machinery, Characteristics, Speed, Tonnage and h.p. per Ton, Computations and Adaptability to Special Service—Hand handling of materials, limits, cost and conditions warranting use of machinery. Continuous conveyors, screw, bucket, scrapers, pusher, belt and pneumatic types. Intermittent conveyors; telephers, rope and cable ways, cable cars. Loaders, unloaders, storage facilities. Skips, grab buckets, tips and tipples. Short and long hoists, friction drum and direct connected hoists. Pneumatic and hydraulic elevators for freight. Fixed and traveling cranes. Passenger elevators, rope and plunger types. Safety devices. Automatic weighers of materials; coal and ore storage systems. Excavating machine and dredges. Coal and ore-handling machinery. Railroad terminal and steamship loaders and unloaders. Coke oven

chargers and dischargers. Grain handling. Special adaptation to material such as sand, plaster, glass, cement, broken rock, coal, coke, packages, barrels, corrosive, erosive, sticky, packing, and hot materials.

Third year Mechanical Engineering.

Shop Processes, Tools and Time Study. Two hours.

The Economic Elements in Shop Processes, Time and Power per Unit of Surface Finished or Cut and per Unit of Metal Removed with the Conditions for Most Economic Production—Processes in the shop, functional operation of machine tools and limits of economic production, time of setting, handling, forming and finishing of parts for job and repetition work in quantity. Limits of time, power and cost for finishing surfaces per sq. in. and removing per cu. in. and per lb. by hand and machine operations. Machine for performing specific operations, their functional operation, capacities, adaptability and rate of production. Conditions warranting jigs and fixtures for the production of parts in quantity and for interchangeability. Economy of portable tools, devices and methods of inspection. The selection of economic cutting conditions and analysis of recent experiments. Adaptation of economic cutting speeds to machine tools. Labor-saving devices in the pattern shop, tools and appliances used, capacity and adaptability; built-up patterns, single-piece patterns, metal patterns, comparative cost and life of each; patterns for repetition work, rights and lefts, a line of sizes, interchangeable patterns, jobbing patterns, relative economy of alternating practice. Economic production in the foundry, relative value of various methods of molding large and small parts, core making, venting, pouring and handling the work, managing the cupola. Limits of labor, power and fuel per ton of castings as affected by size and form and fraction chargeable to pattern, molding and cupola and finishing. Processes of forging, hand and machine, conditions warranting power hammers, hydraulic presses, bull-dozers, presses, dies and forming devices for the production of duplicate and standard pieces. Labor and power per lb. of forging as affected by tools, size and form of work. Heating and annealing furnaces, consumption of gas and oil, labor, power and fuel per unit annealed. Distribution of cost of machine production between different processes, power, labor, material and effect of shop or tool capacity factor on fixed charges.

Organization and Management. Three hours.

Manufacturing Organizations and Methods of Cost Accounting—Effect of methods of manufacture and capacity on systems of management of mills and factories. Analysis of the elements of factory accounting and

determination of the factors entering into the cost of production. Methods for keeping record of the cost of labor and materials in the production of specific articles. The determination of establishment charges. Interpretation of costs and use of comparative values. Determination of costs and use of comparative values. Determination of the depreciation of buildings, machinery, patterns, drawings and other assets. Organization and functions of the departments of the business. Purchase of raw material and sale of product. Utilization of scrap and waste. Methods of labor compensation. Critical analysis of the methods of accounting in representative factories. Factors affecting the cost of production.

Fourth year Mechanical and Chemical Engineering.

Steam Power Plant, Summer Work.

Report based on not less than six weeks' practical work in an Operating Power Plant, including the Output, Load Conditions, Labor and Material for Operation and Maintenance, Operating Cost per Unit and the Essential Dimensional Relations between the Various Units and Auxiliaries Producing this Result—This work is done entirely by the student in the field, his only assistance being the blank report form which is put into his hands after a brief lecture before leaving the University for the vacation.

Third year Mechanical Engineering.

Reference to the catalogue of the school will serve to show how all the courses have been prepared with a view to that interrelation of subject matter so necessary to the broad and comprehensive treatment of engineering problems. While rigorous treatment of the laws of mathematics, mechanics, physics and chemistry obtains in the subject matter of all courses yet the commercial relations and limitations in which these laws operate are as prominently set forth for the purpose of developing that judgment so necessary to their proper use. The foundational principles of engineering practice as in the practice of law are comparatively few while their applications and interrelations are by no means simple nor permit of ready interpretation. Accordingly therefore, that the practice of engineering may be presented from the broader point of view and that the economic and technological aspects may have their fullest meaning, there is incorporated a series

of courses, the treatment of which is according to the system of "Case Law." The limitations of human accomplishment and the necessity for authoritative presentation of subject matter required in the search for underlying fundamental principles have lead to the handling of such courses by men who are daily practicing in each of these fields of engineering service. The work of these special lecturers is not accompanied by any departure from the regular methods of instruction pursued in other courses and is not to be confused with the general system of special lectures in isolated and non-related subjects obtaining in almost all of our universities and colleges. The principles of economic relations intertwining these and other courses of a technological nature together with problems of purely commercial aspect are again brought together for exposition and formulation in courses dealing with the use of materials, machinery and men in administering to the needs of the commonwealth. Thus there has been built that foundation upon which a proper consideration of the problems of production will rest and an adequate treatment has been given to that body of principles which in a narrow sense is popularly termed the "principles of scientific management."

TEACHING SCIENTIFIC MANAGEMENT IN THE TECHNICAL SCHOOLS.

BY H. F. J. PORTER,

Secretary of The Efficiency Society, New York, N. Y.

In order to treat in a logical manner the subject which has been assigned to me I shall first define what I understand scientific management to be and then state how I think it should be taught.

As I understand management, it is the second of the two attributes of government, the first being its form or organization, and the second its function or action. In order to have good government, there must first be the right kind of organization. When such organization operates we have management. We must know, therefore, something about the principles of government before we can obtain proper organization, and after the latter is secured, then management is possible, and how scientific it is, will depend largely on the perfection of the organization. We hear nowadays a great deal about management, systematic, scientific or other, but very little about organization of any kind, and yet, as I have stated, the latter is the more important of the two attributes of government, because without it the former can not be obtained.

Now what is the basis of government which involves these subjects to which I shall direct your attention? Government involves the control or direction of people, and we find when we study its history that there are several kinds of government varying in their fundamental principles, some which include the element of human nature in their program, while others fail to do so; the first, of necessity, bringing about successful results; the others constantly resulting in failure.

In the first place, we know that man is, by nature, a social animal, and as such, seeks the company of those of his fellows

having a common interest. That common interest may be for mutual benefit or for protection from a common enemy. This natural instinct causes men to come together in groups. Now as a natural sequence of this formation of a group for one or the other of the above purposes there is evolved a personality who is generally recognized as best fitted for directing the movement in hand. This is the method of establishing government by leadership through a perfectly natural process. This is the earliest and most primitive form of patriarchal or tribal government, and exists to-day whenever small groups of people have simple matters to be attended to, and even in more complex affairs where a committee takes up a project. It is not, however, a stable form of government owing to the changing interests of the members of the group or their loss of confidence in their leader.

Experience proves also that when a leader finds that he is for some reason losing his power, he makes an effort to retain it and that then usually serious consequences ensue. If, for instance, a rival aspirant to his leadership threatens his overthrow, he resists the efforts to replace him. This resistance leads to his drawing closer to him his adherents and apportioning among them privileges in return for which they agree to control certain smaller groups which he can no longer control. Or it may be that the original group has grown so large that the leader can no longer keep in personal contact with all of its members, and is thus forced to divide among those who, he feels, are competent to assume the responsibility, the control of such groups as become formed by one cause or another. Here, it should be noted, that a radical change has taken place in the form of government, and in this change may be seen a fundamental difference in the principles dominating the two forms, one kind being that of the group voluntarily selecting a leader and, on account of his being their choice, assuming responsibility for him and therefore according him their earnest support; the other, that of the group having imposed upon them the choice of another person and being compelled to do what he, who represents interests entirely different from

theirs, may dictate. This change from volition to compulsion characterized the development in government which took place when a tribe became a nation, and the patriarch a monarch. It is monarchy or oligarchy depending upon whether the ultimate authority is vested in one individual or several. It is the change which takes place in the control of every group when it grows so large that one cannot keep in close touch with all its members. One induces loyal support, the other disaffection; one is, therefore, the absolute antithesis of the other. The psychology of the situation gradually developed a return to first principles by a change to democracy where the people themselves say who shall govern them and what shall happen to them.

In the small industrial groups which formed themselves during the second quarter of the last century throughout the eastern states of our country, the master craftsman and his men worked together in close association and in friendly accord. This was the patriarchal stage of industrial government. When, however, in the middle of the century, the steam engine and the steel rail made industry no longer dependent upon the stream for water power and transportation, factories started up by the thousand at the site of the raw material, and the industrial groups grew to large proportions. So great was the demand for workmen to compose these groups that the supply in this country was soon exhausted, and the labor market of Europe was tapped. Then came about the change in the control of the factory group which I have indicated had occurred in the political group. The master craftsman became the general manager and delegated his authority to a superintendent and foreman, who, instead of being leaders of the groups over which they were placed, became their drivers. This was the monarchic stage in industrial government. The foreign element, of which these groups became largely composed, were accustomed to subservience and readily complied with the form of industrial government which they found established.

Government has always been an art, and probably always

will be as long as human nature is involved in the relationship between the governor and the governed. Nevertheless, out of the experiences of the past there are now gradually being established, certain principles which are considered fundamental in the application of this art. In the days of which we are speaking, however, when men were needed to control and direct these factory groups, no such principles had even been considered. The situation presented thousands of industrial groups composed of hundreds of thousands of subservient individuals to be controlled, without anyone informed of the essential principles of either organization or management, to control them. This situation was met by placing over these groups, men who seemed to possess inherent powers of control. In some instances the self devised methods of these men were successful, but in the great majority they failed. In the latter cases compulsion was resorted to in an effort to make the methods which were applied succeed. When we realize that the individual in the factory is absolutely subservient to this control during the greater number of his waking hours it is evident how serious may be its effect upon him.

So we see that the history of the development of political government has been paralleled by that of industrial government, that human nature is the element entering into both and that the problems involved in both cases are group problems which vary according to the size of the group. In political government, the people, realizing the fundamental fallacy in the change from leadership to ruler, have in part rectified it in practically every country in the world, Russia being now the sole exception, by the substitution of democracy where the consent of the governed must be secured regarding the methods of control which are applied to them. But this change has not come about without the stubborn resistance of the ruler to the abdication of his powers. Nor has the complete change as yet taken place according to its advocates, who claim that the faults democracy now possesses can be eliminated only by the application of more democracy, and that this will come about by publicity of the facts, thus establishing en-

lightened public opinion, which, in the long run, is the impelling force which controls the new system. On this point Hon. James Bryce says in "The American Commonwealth":

"Towering over presidents and state governors, over Congress and state legislatures, over conventions and the vast machinery of party, public opinion stands out in the United States as the great source of power, the master of servants who tremble before it. . . . It grows up not in Congress, not in state legislatures, not in those great conventions which frame platforms and choose candidates, but at large among the people. It is expressed in voices everywhere. It rules as a pervading and impalpable power like the ether which passes through all things. It binds all the parts of the complicated system together and gives them whatever unity of aim and action they possess."

And now since the principles entering political government have been shown to be the same as those involved in industrial government, experience is leading the students of government to recommend that in industrial government similar developments should take place, that compulsory methods should give way to more democratic methods. This thought is expressed in the report of the "Special Committee" appointed by the House of Representatives in Washington "to investigate the Taylor and other systems of shop management" where the statement is made that "government in a mill should be like government in a state 'with the consent of the governed.'"

This nation has changed during the past one hundred years from an agricultural and trading nation to an industrial one. Our legislatures, state and national, are devoting themselves to questions almost entirely affecting our industries. Our public school system, our free press, and our public forms have given the foreign element, which flocked to our shores to meet the industrial demand, an insight into the benefits of self government. These foreigners, for so many years subservient to compulsory control, have become informed as to the principles of political democracy and they have now come to realize that although they are in a free country, yet during the greater number of their waking hours they are under personal control regarding which they have nothing to say. They have become restless, and are expressing their dissatisfaction.

At this very time we see taking place in parallel, two very portentous movements. One is political in which the rank and file of the people of the two dominating parties are led by progressive politicians, who, having a great following, demand that the people shall in no sense be governed, but that the representatives of the people shall carry out the will of the people. They believe that the mass of men are better able to govern themselves than are the few to govern them. That the perils from the ignorance of the governed are less than the perils from the selfishness of the governors. The other movement inspired by the same thought is industrial, led by progressive men in the field of industry demanding that the workers shall be represented in the councils of the employers. Resistance is being encountered by both these movements raised by the interests which have so long been entrenched behind special privilege. Great changes do not take place suddenly. It is well that they should be evolutionary rather than revolutionary. We must now, as students of history and of events and affairs, take cognizance of these movements, analyze them and determine the direction in which they are tending and from our deductions devise methods of directing them.

When we have determined the form of democratic government which we are to have in our nation and in our state and municipal groups, the logic of the situation should lead us to extend it to our industrial groups. We can no longer harbor industrial monarchies and oligarchies in our political democracy. The inconsistency is too apparent to be longer retained. People who have learned to think become discontented with inconsistencies. The psychology of the situation is becoming understood. In dealing with human nature in government the latter must be taken into consideration. Dr. Joseph H. Odell, in a recent address, said on the subject of discontent, "Well, supposing we let it alone, what will happen? One of two things. In the first place it may settle down into a permanent and paralyzing pessimism and consign men to a life of spiritless drudgery. They will become an animate, but

soulless part of the vast mechanism of industrial society. Life, upon those terms, is little better than death. On the other hand, this discontent may become suddenly explosive and result in anarchy. Long brooding over the ills that are not understood, changes a man into an Ishmael and turns his hand against every man's hand. Discontent is a negative quality and when a negative quality becomes active, it grows destructive. We must know how to transmute a negative element into a positive. We must change discontent into desire. We have done this to a large degree in political affairs and we should use the same means in our industrial affairs."

The *form* of our government is its attribute which we call *organization*. Without a well-defined organization we can have no well-defined system of management. A well-defined organization can be shown on a chart and any organization which cannot be thus visualized is defective and the management resulting from a defective organization is bound to be defective.

A government is like a coaching outfit. The coach must be built right for its purpose with all its four wheels of the same size and its axles straight and parallel. The horses must be well matched and strong enough to pull the coach. One must not be a dray horse and another a trotter. The harness must be properly fitted to the horses so that the collars will not chafe and irritate them and the traces must be of the same length, so as to pull evenly and not permit one horse to get his leg over the other horse's trace and interfere with him. If all of these requirements are not met there will be danger of the outfit not running straight. Merely speaking to the horses kindly or patting them on the neck or giving them sugar or plying the whip is not going to reach the cause of the trouble. But when this organization is properly arranged so that everything is in its right place without overlapping or interference, then a skilled coachman may get up onto the box and take the reins and guide the coach over such roads as he may meet. There is some assurance that it will stay in the middle of the road without any

inherent tendency to go over into the ditch at either side. The man on the box is the manager and upon his general knowledge of conditions and his skill in handling his organization will depend the efficiency of its team work. This man is an entirely different one, however, from the one who designed the coach or the harness, although he should have very much to say about the selection of the horses.

It is not my province here to chart the various schemes of organization which are adapted to different shop conditions. It will be sufficient for present purposes to say that, generally speaking, any organization has four basic departments which may be comparable to the four horses of the coach. They are the financial, the sales, the production and the record departments. Each of these should be as independent in its action as any one of the horses, but all should be so related by their harness as to constitute a team.

The duty of the first of these departments is to collect and disburse money; to collect the money for the product which the second, or sales department, has disposed of and to disburse money to all the other departments for the work which they have done. The duty of the second is to obtain orders for work for the third or production department to perform.

This latter department converts the orders received, into finished goods. It is dependent upon the second and the first departments for its existence just as the second and first are dependent upon it, and all three must be so equally balanced as to be normally independent or there will be a maladjustment which will cause trouble.

The fourth or record department is intended to keep account of all that transpires in the other departments so as to maintain this balance. It receives all the raw material; holds it until it is needed by the production department, keeps track of what the latter does with it, takes it back as finished product, hands it over to the sales department and tells the financial department how much it has already cost, how much more it will cost before it is sold and how much should be added for profit in order that all the departments may be kept in good condition continuously.

Now a chart of organization of the kind outlined should be drafted before any industrial enterprise gets farther than the stage of being contemplated in order that it may be properly capitalized and promoted. It is essential that such a chart should exist in every enterprise and be in constant view for reference but I think I am safe in saying that 99 per cent. of the enterprises now in existence have none, and 50 per cent. of the managers have never heard of such a thing. The man who can do this work to-day is rare. He is not taught in any school of which I know. He is the man to develop the organization before which no management, which can have the slightest claim to being scientific, can come into effect. I believe he should have a university education first and a special post-graduate course in business organization subsequently. But suppose we have secured such a proper or scientific organization and we need a man to operate it or perform the work of managing it, what kind of an education should he have? In the first place he should be capable of knowing all about the operation of the organization, *i. e.*, the physical part of the chart so that the finances, the advertising, the selling, the methods of production (including the purchasing), the record keeping (including the stock keeping and the cost accounting) are working as they were intended to work.

There are schools which have been teaching these subjects independently for some time. There are schools of finance, schools of salesmanship, schools of mechanical engineering and schools of accountancy. These schools make specialists, but there is no school that I know of that teaches all of these branches and their interrelations so that there is not, therefore, any school that teaches the elements of management. There are colleges and universities in which lectures in some of these branches are given by practical men who have specialized in them, but from all that I can gather from the graduates of these courses and from the deans of the schools themselves, these courses are as yet only in the primitive or formative stage. So we see that teaching the subject of government, of which organization and management are only parts, has not as

yet been begun. There are not yet, to my knowledge, adequate institutions for preparing men to be managers. Nor are there ways of preparing men to go out into the field to diagnose the troubles which afflict existing industrial enterprises. This will account for the fact that so many essays on the part of "efficiency" or "industrial" engineers fail. They may be competent to improve methods existing in the production department but by doing so they simply over-develop one of the four wheels of the coach which cannot run satisfactorily with one wheel larger than the rest. The financial, the selling and the record departments must be developed equally to obtain successful results, and the education of the day does not equip a man for all these fields. On the contrary, the tendency of the times is to develop specialists.

There have been men who have realized this condition and have organized groups of specialists in these various fields who have been able through the correlation of their efforts to accomplish success where the single specialist who has tried to cover the whole field has failed. This, to my mind, is the best method of reaching the situation in the present emergency. If I am right in my conjecture, efforts should be made to clarify the situation and let it be understood that schools of government should be established and managers should go there to learn the principles of organization and management. When they have gained a knowledge of these principles, they should realize that they will need specialists as heads of their departments of finance and selling, of production and record and they then, and then only, will be able to secure efficient team work. We must realize that the great body of the people are employees and that the employer has a greater effect upon his employees physically, morally and mentally, owing to the continuity of his influence over them during the greater number of their waking hours, than their physician, their minister or their teacher. Each of these must have a diploma or a license, therefore the manager whose responsibilities are greater, should not be allowed to assume them until he is properly equipped to do so. We now know that every ruined health,

every crippled body, every demoralized or warped character, every blunted mind is an industrial or social waste and a charge upon the community, and yet our industrial managers of the past and present have been allowed to furnish this waste in increasing quantities every year. To meet these industrial responsibilities not only calls for a more scientifically-trained intelligence in the managerial chair of the single industrial enterprise than has heretofore been supplied, but it requires a man capable of organizing all the industrial enterprises comprising an industry so that, as a whole, it will be a benefit rather than an injury to the State which grants charters for its existence. To do this properly he must understand the industrial group problems in which his enterprise is a factor.

It is generally understood that a manager of the modern type is meeting the requirements of scientific management if he operates his individual enterprise efficiently by reducing his wastes of time, effort and material to a minimum so that his product can be marketed at a fair profit. As means to these ends he establishes well-constructed factory buildings, he maintains sanitary conditions, he supplies an environment for his employees that is beneficent. He introduces systems of functional management and time and motion study to ensure fair treatment and equable wage determination. He institutes works committees composed of employees and installs a suggestion system.

All of these features are excellent as far as they go, but they go nowhere in meeting the larger serious group problems which exist and which no efforts have as yet been made to solve, and which cannot be solved in any one factory or in any group of factories such as compose a trust, but only in the harmonious coöperation of all the factories which compose an industry through the collective administration of the industry as a whole. A knowledge of how to accomplish work of this kind involves questions of government and embodies studies which have little to do with the scientific management of a shop. They are not especially germane to technical schools, but, beginning in the primary schools and continuing in the

secondary and high schools, should follow in the college, the university and the postgraduate school.

In order that I may make myself clear, let me show by a specific case how intimately the affairs of a community and an industry are related and how helpless is the manager of a single enterprise in that industry with regard to some of the troubles with which he has to cope. The cloak and suit industry in New York City comprises some two thousand shops of various sizes, employing all the way from 25 to 300 hands, 80 per cent. of whom are men. The work is what is termed light manufacturing, in which, outside of what is performed on sewing machines, the work is done by hand. The employees are mainly Italians and Russian Jews. These people came from Europe with their packs on their backs, and went directly into the congested East Side tenements of the city to live and worked in the cloak factories under sweat shop conditions. Many, being of a thrifty nature, saved money until they possessed enough to open sweat shops of their own. Thus practically over night they stepped from the employee to the employer class. All they know about organization and management they learned from their employer, who used sweat shop principles. They felt that the only way they could succeed in the market was by more severe "sweating" than their competitors practiced. The result of this unrestricted competition was starvation wages, unlimited hours of work, unsanitary shops, unhygienic conditions of living and unspeakable misery. Such a state of affairs would have been bad enough if it had been continuous, but each year it was made immeasurably worse by two periods of enforced idleness. The warm weather trade developed a busy season through three and one half months in the spring, followed by two and one half months of idleness in the summer; the cold weather trade caused a busy three and one half months in the fall and two and one half months idleness in the winter. When it is realized that scarcely a living wage was paid during the busy seasons, owing to the overcrowded condition of the labor market, it can readily be imagined how poorly pre-

pared financially the employees were to meet the enforced idleness of the slack seasons. Affairs finally reached such a pass that they could no longer be borne, when a strike ensued. It was one of the most severe ever experienced in New York City. It lasted some twelve weeks, bankrupting many of the employers, while some of the employees died from privation. Finally the merchants who needed the product of the factories brought the strike to a close by the formation of an association of the employers and an affiliation of the various unions of employees. Each of these two bodies appointed two representatives to a joint board and with them on this board they asked three public spirited citizens to sit. This board was asked to consider the situation and recommend remedies.

We are not apt to realize how large some of these light manufacturing industries are. In the one described above, for instance, the 2,000 shops contained 80,000 employees, who, with their families, constituted an industrial community of 200,000 people, as large as the city of Providence or Indianapolis. When we consider that this number of people, or a very large proportion of them, were thrown onto the City of New York for support twice each year and that this is only one of several other industries in which similar seasonal fluctuations occur, it is not surprising that the city's charity organizations are so strained that the almshouse, the workhouse and the jails are crowded; that the gambling house and policy shop and pool room thrive; that the saloon and disorderly house abound; that the bread line and the park bench are filled.

The seasonal fluctuation is only one of the difficulties with which the manager in every industrial enterprise has to contend and which cannot be remedied even by any amount of scientific management in his individual plant but only by a control affecting the whole industry. The democratic principle of having the employee represented in the councils of the industry, works well in the instance just referred to and in others as well. The illustration I have given is only one of several which I might mention of industries which have done

the same thing. But all about us we see wastes occasioned by others who have not done it. By some of these wastes our high cost of commodities is easily explained.

In the block where I live in New York City there are twenty dwelling houses, and an apartment house in which there are twenty-four families. Every morning there come into that block eight different milk companies' wagons, four ice companies' wagons, six grocery companies' wagons, etc. The question of distribution can be settled only by organizing these various industries so that the milk industry, the ice industry, the grocery industry do not duplicate their trucking in such a ridiculous manner. This means that we must educate our people in the principles of political and industrial science, beginning in the primary school and extending all the way up into the postgraduate schools of business administration. People should know that the cure of our present troubles will not be by breaking up our industrial combinations but by fostering further combinations where labor and capital are represented under public supervision. No man should be allowed to become a manager until he has completed a course in one of the graduate schools. No enterprise should be allowed to exist until it has secured a license obligating it to meet certain requirements and if it lapses in observing them the license should be revoked. This is what I think should be included in a knowledge of scientific management, the only kind that will be really effective in the efficient operation of industry.

The Efficiency Society, three months old, with already over 1,000 members, is now inaugurating a campaign of investigation into the results of present methods of management in industrial establishments following up the legislative investigation carried out by Congressman Redfield last winter. A frank and generous contribution of experiences is hoped for by employers, employees, and efficiency engineers. A conference on the subject will be held in the fall, at which time it is expected, sufficient data will have been collected to be analyzed and studied, and deductions made for intelligent discussion. We trust that the results will be most helpful.

A BROADENED VIEW OF EFFICIENCY IN ENGINEERING INSTRUCTION.

BY LEWIS J. JOHNSON,

Professor of Civil Engineering, Harvard University.

I certainly favor efficiency in engineering instruction as well as in other things. I believe that we owe a great debt already to Mr. Taylor, Mr. Gilbreth and the rest for what they have done to wake us up and show us the way on these lines. Particularly do I rejoice that Messrs. Taylor and Gilbreth recognize as indispensable the cultivation of good will between employer and employee by simply making it automatic with honest and intelligent efforts for just and fair relations. They see the moral and human side, hence I believe that they are in a fair way to lead us to success.

But to my mind efficiency is a pretty broad subject, broader than mere questions of economical production and transportation. It involves to an equally high degree the correct distribution of emphasis and attention. This, to my way of thinking, means a high degree of emphasis and attention upon the basic, but sadly neglected (when not misdirected, perverted, or sterilized) lines of activity, political economy and the science of government.

For while, of course, it profits us much to extend our already *relatively* efficient means of production, our work will fall far short of its purpose if we do not do something to put our whole industrial and political structure on a firmer basis through getting in line with the fundamental laws of justice and human nature. If this be done, I feel confident that progress toward self-sustaining industrial order and peace will be not only possible but rapid and certain. Otherwise our present chaotic conditions can hardly fail to grow worse. The "conservative," as he loves to call himself, who

seeks quiet and peace by sitting on the social safety-valve, and his compeer in social value, the man who seeks to secure relief for bad conditions by putting grit into the bearings of his employer's machinery, are both abroad in the world. The normal man must begin to put efficiency into his citizenship if we are to find the true way out.

No one, whether lawyer, clergyman, journalist, office-seeker, office-holder or the ordinary academic essayist, is so well equipped, I believe, to deal with this great field of scientific management fundamentally and constructively as the man with the engineer's or the applied science man's training and attitude of mind. If we are to have a society in which securely to practice the fine and noble art of scientific management in the production of wealth, the scientific rather than the traditional point of view must, in my opinion, get into effect in our biggest and most far-reaching public relations.

Our customary habit of thought in business and commercial relations is still nearly as greedy, because as misguided, as in the time of the Pharaohs. Our political machinery, even in this land of progress, has been but little improved since the invention of the steam-engine. Here I believe is an immense and most promising field for scientific management.

As a first step we should seek and establish a true and sane definition of property. For thus only can the property of the capitalist and of the laborer be secure and a proper economic incentive (and that means a chance for industrial peace) be maintained. This I believe is no insoluble task even if it is largely abandoned for the consideration of far less important matters. In the political field, scientific management would set in motion the old ideas expressed in the Bills of Rights of the early state constitutions. These were particularly well stated a century and a third ago in the Massachusetts Bill of Rights; well stated, but for reasons then unavoidable, imperfectly set in motion.

This subject I venture to bring before the society at this time because here is a body of men whose instincts and habits

are fundamental and constructive—who will quickly see, if they do not already see, that, important as scientific management of the production of wealth certainly is, a scientific management of the distribution of wealth and the maintenance or establishment, if necessary, of peace, contentment and order in society is even more important, and that it is both their right and duty as citizens to do their full share in this work, and perhaps to take the lead.

I think that engineers, if no one else, will dare believe that the distribution of wealth in society can be made as automatic, smooth-working, and satisfactory as the circulation of blood in a healthy animal; that they will realize that such results can come only from proper guidance of natural forces, and not from arbitrary and shallow legislative interference with such forces. I certainly believe that we have only to get in line with the fundamental laws of economics and human nature, and let them, like gravity taking water down hill, do the work. And we need not feel concerned if the school of thought which got humanity into its present and century-old fix, denies the existence of such laws or the possibility of getting into harmony with them.

The work of the next few decades is a new work, a work for applied-science men and others who can comprehend that there can be no social or industrial peace so long as human traditions, conventions and laws are kept flying in the face of the fundamental laws of the nature of men and things. Nothing is so much needed by engineers and applied-science men as a realization of this point of view. It opens to them a vastly broadened prospect of service as citizens and, in common with all other useful workers, greatly heightened satisfactions of the durable sort, to use President Eliot's admirable phrase. Hence nothing can contribute so much to the efficiency of engineering instruction in the biggest and broadest sense, as to make clear to the young engineer-citizens that their training in careful and responsible construction can apply, and ought to be made to apply, to the whole range of civic and industrial problems; and that they need feel neither surprised nor dis-

turbed if popularly accepted "experts," apologists for existing evils, oppose their conclusions. George Stephenson had to struggle hard in the face of the "experts" to get recognition for his "travelling engine," and the responsibilities and opportunities of the civic engineer of to-day are perhaps greater than those which confronted the mechanical engineer, George Stephenson.

ABSENCES FROM CLASSES ONE MEASURE OF INEFFICIENCY.

BY F. P. McKIBBEN,

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To persons in charge of schools or colleges a study of student absences from classes is of great value, because the absences are to a certain extent a measure of the efficiency of the system. If the system is working well there are few absences from classes. If it is jogging along with friction and kept going only by the continuous effort on the part of those in control, the number of absences will be large. Viewed from this standpoint, therefore, efficiency can be said to vary inversely as the number of absences. In analyzing the problem of absences at any institution one should first make a systematic study of the underlying causes. Such an investigation will show that students absent themselves from classes because of the following reasons: Poor teaching; lack of interest on the teacher's part; uninteresting subject matter; sickness, either of the student or of his friends or relatives; conflicts between recitations because exercises in two different subjects occur at the same hour; other legitimate matters which take students away from their work; idleness; laziness; dissipation; and youthful neglect.

There are two general ways of dealing with the absence evil. In one, frequent written tests during the term and a final examination constitute the basis for determining each student's standing. In this system no attention is paid to absences by the instructor except that the student is graded zero at each written test or examination from which he absents himself. Clearly, the effectiveness of this method is dependent upon excellence of instruction and upon keeping the students ignorant as to when written tests are to be given. This is a good system, because few students will be absent if they realize

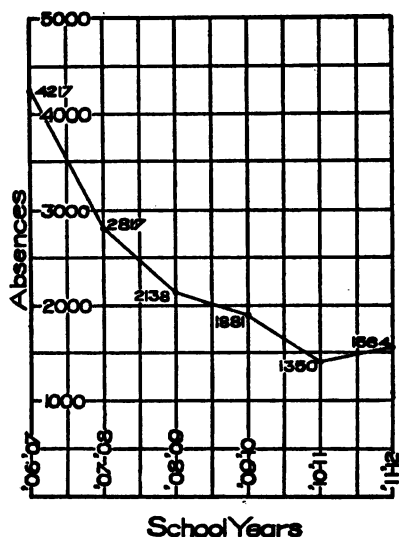
that a written test may be given at any exercise and that an absence from such a test is of very decided value in determining their academic status. The other system, which is in vogue at some schools, is that in which each student is graded

A = Total absences during course. B = No. Students x No. Exercises. C = Percent absences (A÷B)100

Subject	1906-07			1907-08			1908-09			1909-10			1910-11			1911-12		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1st Term																		
Sr. Bridge Des.	349	3240	10.7	172	2880	6.0	110	4536	2.4	103	5184	1.9	71	3132	2.3			
Sr. Sanitary Eng.	235	3312	8.9	155	3020	5.1	134	2880	4.7	101	3240	5.0	97	2552	3.8	87	2160	4.0
Sr. Geodesy	103	2160	9.9	130	2160	6.3	87	2106	6.1	118	1890	6.1	128	2052	6.2	44	1876	2.3
Sr. Graphics (E) & (M)	119	1044	6.1	127	1728	7.3	65	1188	5.5	60	1116	4.5	14	432	3.2	6	324	1.9
Sr. Graphics (E) & (M)																		
Jr. San. Materials	504	6504	7.5	462	8136	5.7	283	8956	3.2	200	7848	3.8	219	8208	2.7	244	6264	3.9
Jr. Cement	102	1764	5.8	69	1546	4.5												
Jr. Railroads	172	1800	9.5	134	1692	7.9	77	1656	4.6	51	1440	3.5	47	1440	3.3			
Jr. Graphics (C.E.)	179	3744	4.8	153	3240	4.7	106	3146	3.4	84	3096	2.7	47	2520	1.9	25	1440	1.7
Jr. Constr'n (E.E.)	38	828	4.6	22	702	2.8	40	1296	3.1	16	720	2.2	9	1108	0.8	6	408	1.3
Jr. Graphics (M.E.)							66	1080	6.1	60	1332	4.5	11	800	1.2	28	1368	2.0
Jr. Fritz Lab.																9	504	1.5
Jr. Roads & Pav'ts																86	1584	5.4
2nd Term																		
Sash Constr'n (C.E.)	80	1800	4.4	50	1650	3.0	37	1872	2.0	27	1440	1.9	16	1368	1.2	17	1368	1.2
Sash Stereotomy	145	3456	4.2	195	3384	5.8	133	3816	3.5	81	3672	2.2	34	2880	1.2	32	1968	1.6
Sash Elliptical																		
Fresh'n Mech. Drg.																		
Totals	2175	30744	7.1	1675	30228	5.5	1147	32432	3.5	1160	32454	3.6	745	30896	2.4	690	24090	2.8
Sr. Bridges & Dams	271	3240	8.4	27	2880	3.4	78	3168	2.5				107	2160	5.0	92	1920	5.2
Sr. Steel Bldgs.	92	684	13.4	23	900	3.1	15	828	1.8				19	766	2.5	15	448	3.4
Sr. Cement													12	2052	0.6	56	1632	3.4
Jr. Hydraulics	500	5994	8.3	339	6372	5.3	291	7020	4.1	305	6480	4.7	178	5778	3.1	324	5572	5.9
Jr. Roads & Bridges	203	2754	7.4	121	2268	5.3	78	2572	3.0	51	2106	2.4	44	1836	2.4	157	2160	7.0
Jr. Ry. Survg. (C.E.)	339	4590	7.4	164	3600	4.6	104	3570	3.0	155	3960	2.9	114	2880	4.0	85	2688	3.6
Jr. Constr'n (E.E.)	57	828	6.9	36	864	4.2	42	1044	4.0	75	792	9.6	14	1008	1.4	16	448	3.6
Jr. Survg. (C.E.)							76	972	7.8	59	1056	5.8	35	648	5.4	7	540	1.3
Jr. Hydr. Lab.																14	720	1.9
Sash Constr'n (E.E.)	136	1620	8.4	72	1512	4.8	161	1872	8.6	46	1440	3.2	20	1188	1.7	53	1216	4.3
Sash Surveying	250	3394	7.4	100	2452	3.7	70	2572	3.0	39	2016	2.4	39	2304	1.7	24	1472	1.6
Fresh. Des. Geom.	194	2658	7.3	100	2700	3.7	84	2262	2.9	36	2214	1.6	51	2312	2.2	30	1032	2.2
Totals	1004	25740	7.9	1142	25020	4.6	1997	50514	3.7	1712	19656	3.6	1605	22814	2.7	1575	19528	4.4

Student Absences from Classes, C.E. Dept., Lehigh University.

frequently during the term upon daily recitations and upon written tests regarding which he has been previously informed as to their time of occurrence. In this system a number of absences is fixed for each subject, constituting a maximum limit beyond which the student must not go in absenting himself from class without suffering the penalty imposed for exceeding the limit. The penalty usually consists in exclusion from the final examination in the subject in which the absence



*Total No. Absences from all Causes
Civil Engineering Dept., Lehigh University.*

limit has been exceeded and the limit bears a certain relation to the number of exercises per week in the subject. For example, if there are three recitations per week in a subject the exclusion limit might be fixed at six, which is double the number of exercises per week. This ratio is too high; four would be a better absence limit in such a case. The very existence of an absence limit makes some students feel that they are allowed to take these absences, even though their

grades for exercises from which they are absent be zero, hence, this system is conducive to absences on the part of a few students if for no other reason than the inherent disposition in man to take all that is coming to him. Some students do not realize that the absence limits set are to meet unforeseen and unavoidable contingencies. It is unfortunate that the great number of worthy and careful students should be subjected to strict rules simply because there are a few irresponsible members in their ranks.

Believing as I do that absences are conducive to the formation of bad habits, which take time after graduation to overcome, and that an employer notices in many ways the effect of "dilly-dally" habits formed in college, I have tried to reduce their number in exercises taught in the civil engineering department at Lehigh University. That the effort has been successful is shown by the accompanying diagram and table, wherein it appears that in the six years beginning with the college year 1906-1907 the total number of absences in the department has been reduced from 4,217 in that year to 1,564 in the year 1911-1912. During this same period the percentage of absences has fallen from a maximum of 7.9 in the second term of 1906-1907 to a minimum of 2.4 for the first term of 1910-1911. The percentage of absences in any term is obtained by dividing the actual number of absences in all subjects by the product of the number of students and the number of exercises, and multiplying the quotient by 100. In the accompanying table every absence from exercises in the civil engineering department is included, whether occasioned by sickness, neglect, athletics, conflicts between two different subjects occurring at the same time; in fact, from every cause whatsoever.

This reduction has been accomplished by showing the students that it is for their good that they be present, by publishing the figures to show that an evil existed, by trying to make the exercises so interesting and important that students wished to attend, by unceasing watchfulness over and persuasion with those who showed carelessness, and finally where all

EXCLUSION. ABSENCE LIMITS FOR SUBJECTS TAUGHT BY CIVIL ENGINEERING DEPARTMENT, LEHIGH UNIVERSITY, 1911-1912.

	Subject.	Class.	Number of Exercises per Week.	Exclusion Limits.
First Term.	Bridge design.....	Senior	6	7
	Sanitary engineering.....	Senior	4	6
	Geodesy.....	Senior	3	5
	E. M. graphic statics.....	Senior	2	3
	Strength of materials.....	Junior	4	6
	Testing laboratory.....	Junior	1	0
	E. E. construction.....	Junior	2	3
	Roads and pavements.....	Junior	2	3
	C. E. graphic statics.....	Junior	2	3
	M. E. graphic statics.....	Junior	2	3
	Elem. mech. of materials.....	Sophomore	1	2
	C. E. construction.....	Sophomore	2	3
	Stereotomy.....	Sophomore	3	5
	Mechanical drawing.....	Freshman	2	3
	Subject.	Class.	Number of Exercises per Week.	Exclusion Limits.
Second Term.	Bridges.....	Senior	4	5
	Cement and concrete.....	Senior	3	4
	Steel buildings.....	Senior	2	3
	E. E. construction.....	Junior	2	3
	Hydraulics.....	Junior	3	4
	Bridges.....	Junior	3	4
	Railroad surveying.....	Junior	4	5
	Hydraulic laboratory.....	Junior	1	0
	C. E. construction.....	Sophomore	2	3
	Land surveying.....	Sophomore	4	5
	Descriptive geometry.....	Freshman	3	5

other means failed by enforcing strictly the rule regarding exclusion from final examination where the absence limit had been exceeded. This exclusion meant that the student under discipline was compelled to repeat the subject in class. A very forceful argument that sets the students to thinking about this matter is that pertaining to the financial aspect of the question. Let it be supposed that a student has 18 class exercises each week for 30 weeks or 540 exercises during his college year and that the total cost of his year's stay at college is \$810.00. If he is absent once he has wasted \$1.50, assuming that each exercise is of the same importance; 10

absences means the loss equivalent to \$15.00. Of course, the reasoning here is far from logical, because a boy will not lose the entire lesson by being absent from the recitation if he has devoted some thought to the lesson at home, but there is just enough basis for the argument to make some students understand the point involved and to make them improve their attendance.

THE PROBLEM OF EFFICIENCY IN TEACHING.*

BY W. A. HILLEBRAND,

Professor of Electrical Engineering, Oregon Agricultural College.

President Jordan, of Stanford University, tells the story of a prominent entomologist who began his study of organic science under Professor Agassiz. The young man was at first given a fish to study with the brief instruction to find out by observation all that he could about it. After some twenty minutes or half an hour he reported to his instructor, only to be told to go back and look some more. His real observation began when he picked up a pencil and commenced to draw, but after noting with painstaking effort apparently all that the exterior of the specimen could reveal, he was informed that he had overlooked the most significant fact of all. For two days he pondered over the enigma until it occurred to him in a dream, that the fish is symmetrical. In his stubborn insistence that the student work out his own salvation, backed doubtless by a personal magnetism that spurred him to the effort, lay the genius of Agassiz as a teacher and in that same spirit lies the essence of good teaching today and for all time.

Most people acquire knowledge of a new subject slowly and with difficulty and what a student does acquire he must win for himself, as a rule laboriously. How true this is will be vouched for by any teacher who holds himself responsible for seeing that his students absorb the information which he strives to impart.

In a recent article Professor Paine, of the University of Illinois, describing the work in that institution, cites the daily

* This paper was first presented, by request, at the December meeting of the Portland section A. I. E. E., and subsequently printed in abstract in the *Journal of Electricity, Power and Gas*.

problem as an essential feature, whereby, to use his own words, "The student finds out for himself," a laborious process but, where effectiveness is the goal, the only one which the author believes practicable.

In my own classes I have for five years given the following problem:

"An arc light which behaves as a dead resistance consumes seventy volts at the arc with a current of six amperes: Find the reactance in ohms of a choke coil to be placed in series in order that the arc may operate properly from a one hundred ten volt circuit." Each year regularly fourteen out of fifteen men will add algebraically the reactance and resistance volts, although for a week or ten days they have been successfully solving problems with complicated series and multiple groupings of resistance, capacity and inductance. A similar experience would await when, later in the semester in the study of transmission lines, the reactance and resistance drop would again be added algebraically. All of these problems had to be corrected and returned by the student and much time could have been saved to all concerned by a word from the instructor.

When this fact concerning the difficulty with which knowledge is acquired is once accepted, it becomes the fundamental, underlying principle of any educational institution that adopts it and largely determines some of its most important pedagogic questions such as the attitude of the student toward his work, of the teacher toward the student, and the provision of adequate funds that the work of instruction may be prosecuted in accordance with the accepted ideal. It will be an important factor in deciding how a given subject shall be presented by the teacher, that is, whether the best results are to be obtained by lectures, recitations from a text book, a course of problems, laboratory experiments, or through a combination of these methods. The questions concerning the number of students in a given course who can be effectively taught in a single section, of the number of sections that, with justice to all, particularly the instructor, one

man can handle, and also questions as to whether the faculty of any department is undermanned and of whether funds of the institution shall be devoted to extending the work to new departments or strengthening those already in existence, are problems which may be solved intelligently only through the application of our guiding principle.

In considering the question of the efficiency of technical instruction, on which alone the author claims to speak with any authority, two important facts must be borne in mind: First, that in most of the colleges in America which offer technical courses, instruction in a large number of quite unrelated branches is also given; and secondly, that every college is in honor bound to its students whom it ostensibly prepares for life, to offer in every department of its curriculum a minimum number of courses which the nature of each subject and the precedent set by other schools of similar grade have declared standard. For instance, in electrical engineering there must be offered in the junior year an introductory course of lectures or recitations with correlated laboratory instruction in dynamo electric machinery, followed the next year by similar but more advanced courses and one course in the elements of engineering practice as applied to enterprises which utilize the electric current. More can be and generally is offered but this is the irreducible minimum which the institution obligates itself to undertake as soon as it advertises a department of electrical engineering.

Like its near relation, the business corporation, nearly every educational institution has but limited funds with which to carry out the plan definitely outlined in its founding grant or by the policy of its governing board. It inevitably follows, that if an aggressive and capable departmental head in Greek, botany, or mathematics is unduly favored with appropriations to expand the work which he so successfully directs, every other department of the university or college must suffer in proportion as its own income is thereby depleted.

Upon every department head or faculty therefore, devolves the responsibility of analyzing their particular situation, of

deciding upon the minimum equipment and personnel necessary to adequately serve the students as local conditions demand, and to insist that the necessary appropriation be granted. To prove one's case is often by no means easy, especially in view of the fact that other departments doing a somewhat similar work may be handling relatively much larger numbers. Accordingly, during the fall of 1910, the author made an effort to determine the amount of time actually taken by the courses he was conducting, with the idea of determining the number of courses and students which one instructor under similar conditions and with like ideals, can handle.

For an entire semester, or nearly four months he kept a detailed record of the disposition of his time, itemized under headings which endeavored to account for every period of the working day, down to as brief an interval as five minutes. Upon a sheet of paper on his desk was recorded the time of every interruption of routine work or of every change from one form of activity to another. When away from the desk similar record was kept in a memorandum book.

Time was charged against the following, and averaged, in some cases, for a week of five days, although the record comprised the entire seven, but as class instruction covers only five days it is assumed that work for the university was performed in that time, in order to give a standard day.

	Hours per Week.	Hours per Day.
1. Preparation for class	5:45	1:09
2. Class-room instruction	5:45	1:09
3. Correcting reports and papers	17:35	3:31
4. Interviews	9:20	1:52
5. Miscellaneous	11:55	2:23
Total	50:20	10:04

It was not until after my record had been completed, that, in reading Bulletin Number Five of the Carnegie Foundation, I discovered that Mr. Cooke had obtained similar information, with a doubtless similar purpose, from the physics teachers at the eight institutions which he visited.

This shows a heavier schedule than was actually carried, owing to the fact that preparation and correction of reports were carried on over Saturday and Sunday, but is fair if it is understood that the last two days are left absolutely free.

During the five days of instruction an uninterrupted period of not more than two hours could be counted upon.

About three quarters of an hour a day were occupied in conferences with other members of the same or allied departments, which, although conditions were exceptional, was altogether too much. The author was a prime offender.

The amount of time, over an hour a day, devoted to student interviews and the number thereof, which would run as high as eight or ten in a single day, seems unavoidable when the nature of the course is considered. The students had two laboratory periods a week with an inflexible ten-day limit for reports, in which were to be answered numerous questions concerning apparatus handled in the laboratory experiments. In view of this fact and of the exigencies of schedule it seemed impracticable and unfair to keep office hours at which time only consultations might be held. This meant a reduction in efficiency on the part of the instructor, but it was considered essential to the best interests of the student.

As it stands, the schedule is too heavy because time should be allowed him for study and investigation outside of that which he may feel inclined to take from his family and social duties. This is necessitated by the demands made upon the engineering teacher by his college, which requires that he keep up to date, by the profession which looks to him as an authority on the theoretical side which the man in practice often lacks the time to study, and by his students who come to him with questions on a wide range of topics. In my opinion, six hours a day is as much as any man in the teaching profession should be required to devote to work of instruction either by way of actual teaching, conference, or preparation.

The courses conducted by the author, either solely or in conjunction with others, were as follows:

1. A course of lectures to freshmen requiring two hours a

month and a total of thirty hours for the semester in conferences.

2. A recitation course to fifteen seniors of three periods a week on alternating current machinery. There were assigned five problems and six examinations, making a total of 165 papers whose correction required an average of fourteen minutes each. Each problem submitted had to be returned by the student, if incorrect, until marked satisfactory.

3. Laboratory course to the same fifteen seniors, in which twenty experiments, each requiring a report, were assigned. My share was the reading of these reports, which were first handed in preliminary to the experiment and then after performance, resubmitted until accepted. Three hundred reports averaged forty-one minutes each—total time.

4. Course of lectures to twenty juniors, one period a week. Nine reports required, one hundred eighty total, averaging eight minutes each.

A few words as to the conduct of these courses are now in order. Numbers three and four constituted the burden of the work. They were closely correlated, laboratory instruction in a given subject preceding the class room study thereof by one or two weeks, it being our belief, supported by experience, that although it increased the difficulty in preparing for and running an experiment, such difficulty was more than compensated by the advantage to the student in having had some physical contact and experience with a machine before attempting to master the theory.

An idea of the effort that was made to force the student to do as much as possible of the work himself and develop his power to observe and reason, is given by the following incident. One of the boys stepped into my office for information which could have been briefly and directly given but instead, eighteen minutes were consumed in an effort to make him solve the difficulty for himself. All work submitted by the student was rigorously scrutinized throughout and no observed error in spelling or grammar was allowed to pass uncorrected, but the opportunity which such a series of reports offer as studies

in composition was not taken advantage of for lack of time.

An attempt will now be made to determine the amount of work of the sort previously outlined which one man can effectively handle, it being assumed that similar ideals and methods will be adhered to, and that six hours shall constitute a day's work.

Then, one instructor can read the reports on seven experiments performed per day in the senior laboratory, provided he does nothing more. The extra hour is allowed for conferences. If he also handles the section during the three hour laboratory period, then he can read the reports of three or four men. If he is in charge of the laboratory and responsible for the coördination and development of its facilities, the burden of report reading should be largely taken off his shoulders, entirely so if he conducts any other courses besides this one. In a progressive institution, whether it be rapidly growing or not, the work of coördination and development will easily take from one quarter to one third of a man's time, even if he has a mechanical assistant to attend to that end.

In the class room study of machinery performance, a class of thirty juniors or seniors should be split into two sections, for the weight of authority agrees that for most instructional work of any kind, wherein the work is of a nature that requires personal supervision, the limit of efficiency is passed when the number of students in a section is more than twenty-five. Two such sections, meeting three times a week, can be handled profitably by one man whose time will be completely appropriated in preparation, recitation and correction of papers if daily problems are assigned which must be successively returned by the student until correct. His time will be consumed as follows, for the week:

Preparation	3 hours.
Class	6 hours.
Correction of papers, $3 \times 30 \times \frac{1}{2}$	$22\frac{1}{2}$ hours.

or the total of $28\frac{1}{2}$ hours out of a maximum thirty allowable.

Since ample time is to be allowed the instructor in which properly to do his work, equal justice must be granted the student, which means few credits, preferably not over fifteen or sixteen in the junior and senior years, and, in the case of men who will take proper advantage of their opportunity, often a less number is profitable in promoting more intensive study and effort.

If, in such a course, the assignment of one or more problems every day is deemed neither necessary nor desirable, then more time for other work is left both student and instructor.

Assuming three men to handle the above group of seniors, in a laboratory course wherein each student spends three hours a week, and one recitation course of two sections, meeting three times a week, which would be a light schedule for so many instructors, it is seen that in a year of thirty-two weeks, five thousand, seven hundred sixty (5,760) student hours of instruction will have been offered, or nineteen hundred twenty (1,920) per man. By a student hour is meant one hour nominally spent by a student with his instructor.

In the courses given by the department of electrical engineering at the Oregon Agricultural College there will probably be offered this year, seven thousand, three hundred (7,300) student hours of instruction, or with a faculty of two and two thirds men, for two instructors are shared by this and the department of physics, twenty-seven hundred forty (2,740) student hours per man. The imaginary schedule is admittedly light, which places our Oregon institution almost in the same class, as regards opportunity.

Since the question of efficiency in teaching is inseparably bound up with that of finance which provides the necessary funds, it should be of interest to ascertain, if only in an individual case, what the cost of instruction may be or actually is.

The courses offered by our department this year are as follows:

Junior laboratory course	2 semesters, 2 credits each.
Junior recitation course	2 semesters, 3 credits each.
Senior laboratory course	2 semesters, 2 credits each.
Senior recitation course	2 semesters, 3 credits each.
Senior design course	2 semesters, 2 credits each.
Senior thesis course	1 semester, 2 credits.

In the junior class there are eighteen men and in the senior class eleven with a total of 7,300 student hours and 413 credit hours, which totals can not be deduced alone from the above table.

The cost of instruction is subdivided as follows:

Teaching salaries, labor and supplies used solely by the department in connection with the above enumerated courses	\$4,325.00
College administration and maintenance, electrical department share	869.00
Fixed charges, interest and depreciation	1,360.00
Total	<u>\$6,554.00</u>

Administration and maintenance cover the expenses of the executive, registrar and business offices, publications and care of grounds apportioned in the proportion of the number of students taking work in our department to the total registration. A better division would perhaps be founded on the proportion of student hours instruction to the total for the college, but these figures are not available. This item of expense also covers janitorial service and heating, apportioned in the ratio of floor space occupied by our department to the total floor space, estimated, of the college.

Fixed charges include interest at four per cent. This figure is the one used by Mr. Cooke in his report to the Carnegie Foundation. It seems legitimate to charge interest because the college plant was provided by the taxpayers of the state with funds which might otherwise be productive.

Depreciation is figured at the following rates: buildings, 2 per cent.; electrical equipment, 5 per cent.; power plant, 5 per cent.; wire plant, property of college, 8 per cent.; heating plant, 4 per cent.; printing office equipment, 5 per cent.

(a) Students enrolled in electrical courses	30
(b) Total enrollment of full course students	1,066
Ratio, $a/b = .0283$, or 2.83 per cent.	
	Sq. Ft
(c) Floor space occupied by department	4,135
(d) Floor space, class rooms, laboratories and offices in Mechanical Hall, home of electrical engineering department ..	17,230
Ratio, $c/d = .25$, or 25 per cent.	
(e) Floor space for entire college (estimated)	353,000
Ratio, $c/e = .012$, or 1.2 per cent.	

Fixed charges were computed and apportioned to the department as follows:

Mechanical Hall, $\$30,000 \times (.02 \text{ plus } .04) \times .25$	\$450.00
Departmental equipment $\$8,500 \times (.04 \text{ plus } .05)$	756.00
Campus lands, $\$15,000 \times .04 \times .0283$	17.00
Power plant, $\$19,000 \times (.04 \text{ plus } .05) \times .0283$	48.00
Wire plant, $\$5,000 \times (.04 \text{ plus } .08) \times .0283$	17.00
Heating plant, $\$34,000 \times (.04 \text{ plus } .04) \times .012$	32.00
Printing plant, $\$5,500 \times (.04 \text{ plus } .05) \times .0283$	14.00
Administration offices, $\$5,500 \times (.02 \text{ plus } .04) \times .0283$	17.00
	<u>\$1,860.00</u>

Although the estimated value of land on the campus is about \$200,000.00 only the approximate purchase value was used in computing cost.

	Per Cent.
Ratio salaries, etc., to total cost	65.5
Ratio administration and maintenance to total cost	13.6
Ratio fixed charges to total cost	20.9

Cost per student hour, $\$6,584.00 \div 7,300$ equals \$.90.

Cost per student credit, $\$6,584.00 \div 413$ equals \$15.95.

For every registered hour a student spends with an instructor in our department it costs ninety cents. It is interesting to note that this value lies within the range reported by Mr. Cooke as the cost per student hour in physics at eight prominent Eastern and Middle Western colleges and universities. His costs average \$.87.

Assuming that the salary roll should vary about as the number of students, the cost of instruction may be represented by the following formula, where x equals the number of credit hours in courses offered by the department:

Annual cost = \$2,259.00 + 10.50 x .

10.50 covers salaries, etc., per credit hour in 1911-12. The amount which annually must be provided to run the department is given by the formula

$$899 + 10.50x + y,$$

where y is the annual equipment appropriation, which may vary from nothing to whatever the authorities feel can be afforded.

Doubtless the most perplexing question confronting every college president concerns the distribution of the annual appropriation. The author believes that a careful analysis of costs would be of material assistance in answering this question, and that, in general, a low cost per student hour will be a sign of inefficiency.

In striving for efficiency in teaching as in any other endeavor, we believe it necessary to possess a clear realization of the end sought, of the method which shall be followed and of the equipment and personnel required. Some conception of the necessary expense is also considered desirable.

THE ADMINISTRATION OF COLLEGE SHOP LABORATORIES.

BY W. F. M. GOSS,

Dean of the College of Engineering, University of Illinois.

The shop laboratory has for many years constituted an important factor in technical education. The Worcester Polytechnic Institute, which began its work in November, 1868, gave a prominent place to such laboratories. A shop laboratory was organized at the University of Illinois in 1870. An elaborately equipped shop for the administration of graded courses of practice, in conformity with the so-called Russian system, was established at the Massachusetts Institute of Technology in 1876, at Purdue University in 1879, and soon after in various state universities and in other institutions.

Several important results have followed the establishment of these shop laboratories. Their work has interested the public. In the early development of engineering courses in the state institutions of the Mississippi Valley and the West, it was important that the work undertaken should be readily interpreted by the public. The forgings, the patterns, the castings and the finished machines resulting from the work of students in the college shops were accepted by the supporters of these institutions as evidence of the practical character of the work done by the college. Many institutions which began with the simple processes of the shop, have so stimulated the confidence of their supporters that they have been able gradually to build up courses of greater breadth and value. It is especially true of the state universities, that the shop laboratories, with the field instruments used in surveying, have served as stepping stones in the upbuilding of the present-day broad and admirable courses of study and practice.

Advocates of the movement have looked upon the work of

the shop laboratories as of the highest importance from an educational point of view. Such work has trained students to an understanding of the nature of materials, and has afforded them practice in many of the fundamental processes which underlie all construction. Its purpose has been not to make men skilful manipulators, but to give them an understanding of the principles governing manipulation. Not only have the shop laboratories accomplished this purpose, but they have bestowed upon students certain incidental advantages. The fact that a graduate in mechanical engineering has been able to run a lathe has often supplied a way for his admission to an establishment, in the management of which he has later become an influential factor. In the early days of the technical school, the fact that the engineering graduate could make tests and calculate the efficiency of a boiler, counted for little, but the fact that he could take his place in a shop and do things which the practical men of the shop were paid for doing, at once gave him value in the opinion of the men who were influential in determining his future career.

Many changes have affected the engineering industries since shop laboratories first made their appearance, and many new conditions have arisen which must be taken into account when one attempts to define the present-day conduct of such laboratories. Much of the shop work formerly done by the college is now being very well done by the secondary school. The practicing engineer and the corporation manager, who employ the technical graduate, no longer require him to be a skilful manipulator. The employer is now willing to accept at its face value a candidate's ability to apply correct theory in the analysis of practical problems, and he does not insist that he shall be able to compete with skilled workmen as a workman. A demand has developed for men possessing other characteristics—the characteristics of the well-trained theorist and analyst—for men who understand the principles underlying the work of the mechanic, and who through the application of these principles can aid in a large way in increasing the efficiency of the establishment they serve. The people

contributing to the support of the technical school no longer require the activities of the shop laboratory to convince them of the value of the engineer's training, for they see in the work of men who control the engineering activities which are going on all about them, a better and a broader definition of the true functions of the engineer.

From these considerations it should be apparent that the ideals which hitherto have stimulated the work of the shop laboratories are sustained by arguments which are losing force as time proceeds. So true is this that the question is already fairly before the technical school as to whether the existing shop courses which have served so long and so well shall be entirely abandoned. If not abandoned, they must be placed upon a new plane of excellence.

In the opinion of the writer, the time has come when the shop laboratory should cease to be content with a grade of work possible in a secondary school; its work should possess a quality and character which is only possible in the environment of the technical school. This implies that the work of the shop laboratories must be interrelated with that of other technical courses, that such laboratories must cease to use equipment which was purchased one or two decades ago, and that they must cease to be satisfied with methods of administration which, in the actual shops, have already passed out of existence. If the shops are to mean anything worth while, they must not only respond to the great and significant changes which have been going on outside, but they must have their part in leading such changes. Their work must not stop with a routine; it must proceed to the development of research that new principles may be established. This means that the administration of laboratories which are to serve such purposes must be in the hands of broadly trained men and that sufficient funds must be available to permit their operation on a scale far beyond that which most of our institutions have as yet thought possible; it means that such laboratories will take their place with courses of instruction touching the principles underlying systems of shop production just

as the steam-engine laboratory has taken its place in connection with class room courses in thermodynamics.

This conception makes the problem of the modern shop laboratory one of large proportions, and its solution presents a field of endeavor which the officers of technical schools will find full of promise.

SETTING TASKS FOR COLLEGE MEN.

BY SANFORD E. THOMPSON,

Consulting Engineer, Newton Highlands, Mass.

In nearly all colleges there are certain studies designated by students as "snap" courses. Where the elective system is in full force, it follows inevitably that a student can select courses that will permit him to obtain a degree with a remarkably small amount of brain exercise during any one of the four years of residence.

At the Massachusetts Institute of Technology, the institution with which I am most familiar, and I presume also at other technical universities, "snap" courses are hard to find. For the attainment of a degree in science, a student must follow lines of study which are closely prescribed. Yet even in these schools, noted for their "grinds," there is a marked difference between the amount of work required by different departments and by different instructors in the same department. Furthermore, different lessons and exercises in the same course frequently vary to a great extent in the time required for preparation or performance.

Partly as a result of such variations, a common complaint of employers of college graduates and technical school graduates is on the ground of the inability of the latter to attack a job in a business-like manner and complete it in a reasonable time—their lack of "know-how-to-work." Frequently along with this is the failure to realize that a simple error in addition or subtraction may be even more serious from a commercial or engineering standpoint than an error in method of computation. In filling positions in my own organization where the applicant is a recent graduate, my first question is with reference to what practical work he has done before or during his college course; can he turn out a piece of work

not only in the proper way, but quickly and accurately! We frequently hear the statement—true, however, only with a portion of the students—that a man is not good for anything until he has been out of college at least two years. For an engineer, a knowledge of mechanics is a fundamental requirement, but except where mathematical analysis is required, I prefer to instruct a man in method rather than in accuracy and speed. He will learn the former quicker than he will the latter.

The problem of developing more fully this power of accomplishment is no simple one, and I do not refer to the matter in a spirit of criticism—I speak from the standpoint both of an employer and of a lecturer in two universities—but with a view to calling more definite attention to this point, with the object of suggesting a definite line which may be followed for inducing improvement.

The difficulty of estimating the task of a student in shop work by guess was called to my attention recently in a technical school which I was visiting with a class of graduate students from a neighboring university. The task given to the boys was the making up of wooden boxes, and the time to make up two boxes was estimated at $1\frac{1}{2}$ hours. The boys knew they were being watched and, boy fashion, tried to make a record. One of them completed his first box in 12 minutes and his second in 11 minutes, about one-fourth the time scheduled. This boy worked too fast, at a speed greater than he could maintain throughout the day and produce good results. On the other hand, the estimated time was unquestionably too large. The proper time for the task lay somewhere between the two.

In the shops of one large institution in this vicinity—and I am told that it is one of the few in the country which go as far as this—the instructor has scheduled the time that it ought to take for each of the regular pieces of work to be done. While not given specific times for the tasks, the student is expected to accomplish a certain amount of work during the term. This is a step in the right direction. It would be

still better for the instructor to have records based on unit times, which should be so accurate that the student could accomplish each job within a definite fixed time, a record of his actual performance being kept on file.

To see how some of the students actually worked, compared with the task that would be expected of a machinist working under scientific management, one of my assistant engineers made time studies of certain operations in the shops referred to. These times were then compared with the times that would be fixed in practice for such jobs for a man to do the work and receive a bonus. In one case the result was very good indeed, the student's time being 43.2 minutes against a task time of 30.2 minutes. The ratio between these is no more than would be expected between an average man and a man working under task and bonus. In the other case the student occupied four times the task time. The times of the operations are given in the following table. The unit times are not given individually but are grouped together into definite operations for comparison.

In the operation of the task in practice, the man must turn

BORING A $\frac{3}{8}$ " AND A $\frac{1}{4}$ " HOLE COMPLETELY THROUGH AND A $\frac{1}{8}$ " HOLE $\frac{1}{4}$ " DEEP IN A PIECE OF CAST IRON 4" \times 1 $\frac{1}{4}$ " \times 1" THICK.

Hill & Clarke High Speed Drilling Machines.

	Student's Time, Minutes.	Task Time, Minutes.
Drilling 3 holes	6.47*	1.44
Clamping and handling piece	12.76†	1.03
Setting drills and drawing center	13.55	3.30
Changing drills	1.70	1.13
Reaming	4.97	4.00
Cleaning up and lost time	5.12	...
Total time	44.57	10.90‡

* Includes 2.14 minutes calipering hole.

† The bed of student's drilling machine was not adjustable for these times, while the task times are given for an adjustable bed. This accounts for a considerable part of the difference in this item.

‡ Includes allowance for lost time and delays.

MAKING LIVE CENTER FOR 12" REED ENGINE LATHE FROM $6" \times 1\frac{1}{4}"$
DIAMETER PIECE OF MACHINERY STEEL.

Reed 12" Engine Lathe with High Speed Tool Steel.

	Student's Time, Minutes.	Task Time, Minutes.
Preliminary work (getting correct taper) etc.	7.56	5.00
Rough turn, main portion	5.00	3.70
Finish cuts, main portion	3.02*	4.62†
Turn small end	2.10	0.50
File and fit	7.45	3.50
Rough turn joint	4.25	1.65
Trim joint	3.62	2.50
Adjusting tools (operations not exactly alike)	4.97	7.50
Turning end for end and handling	1.26
Extra work and lost time (including handling)	5.28	...
Total time	43.25	30.23‡

out a product of a definite quality and in a definite time in order to receive his bonus. Why in such work as the shop and the laboratory, where the same pieces of work occur year after year, should not the tasks be set in advance, not simply according to the judgment of the instructor, not by records of past performance that may or may not be accurate, but by a really scientific analysis?

That this can be done is not merely theory, for it has been worked out to a limited extent in practice. In a certain school, tasks in the chemical laboratory were set by actual time study. Such work as this naturally lends itself to exact analysis. In another case, tasks were worked out in classes of work that at first thought would seem not susceptible of scientific analysis, viz., the reading and studying of scientific text. In both instances the work was carried out by Mr. Hollis Godfrey, who was at the head of the department of science in the institution referred to.

For a period extending over three years, studies were made

* Making one rough cut and one finish cut at same feed as for rough cut.

† Making two finish cuts at less feed than for rough cuts.

‡ Includes allowance for lost time and delays.

on the times taken by the slow, the quick, and the average boy and girl, to perform the routine experiments in the chemical laboratory, and out of some seventy tasks set on the basis of these tests, only three were found to be too long for the average student. The tasks were figured with an allowance for discussion of work by instructor and another allowance for writing out notes so that the slow student was required to devote extra time to his work. One of the assistants was given the function of seeing that the chemicals and supplies were provided for each exercise to avoid delay on that account.

For the setting of tasks for reading or studying scientific text, 100 pupils were timed to find how long it took them to read a certain number of pages for the first time, the second time, and the third time, it having been found that three readings were necessary on an average to assimilate matter of this character.

For other classes of study, such as the reading of literature or the reading of history, a fewer number of readings would naturally be required and a different time per page.

For mathematical calculations, such as slide rule work and compiling of tables requiring multiplication and division, I have found it possible to set tasks in my office, paying for this clerical work in accordance with the actual amount of work accomplished.

These illustrations are cited simply for the purpose of indicating the possibility of setting tasks for work done with the brain alone as well as that done with the hand or the machine.

If I am correct in my criticism, that different lessons and courses in different departments permit a wide range in the amount of work required by the students, then the problem is worth consideration. Like any problem worth studying, the solution cannot be given offhand, and only general suggestions can be made as to the method of handling it.

In our schools and colleges more attention is being given to the personal element. In our city schools we now frequently find a vocational department. It should be possible to take

another functional step in the direction I have named by delegating to a definite group of men the function of studying and comparing the work required by the different courses and departments. To do this properly, a scientific analysis must be made and time observations taken upon students. Then with the advice of the individual instructors the courses could be definitely planned. Just as the task time fixed for certain machines and men in one shop may be applied to similar machines and men in another shop, so having once determined the unit times for a certain course, the same units could be readily adapted to a similar course in other schools.

In making this suggestion, I am well aware that I shall be met with the stereotyped objection that "you can set tasks for other kinds of work but you can't set tasks for this," but from my experience I know that it is possible to make a scientific analysis and to set tasks in practically all kinds of work. It may not be economical to set tasks in all kinds of work—in cases for example where the operation is repeated only occasionally. If a course of study or laboratory or shop work is outlined simply for a single year and is not to be repeated, there may be a question whether the setting of tasks is worth while. If, on the other hand, as is usually the fact, the same course is repeated year after year with only a few changes, that can readily be provided, for if the analysis of the operations has been properly made, the scientific layout of the work is practicable.

DEPARTMENTAL ORGANIZATION AND EFFICIENCY.

BY HUGO DIEMER,

Professor of Industrial Engineering, Pennsylvania State College.

During the past three years in conducting the department of industrial engineering at the Pennsylvania State College, we have held regular weekly meetings of the department. At these meetings there has been the freest discussion of questions of policy and organization, as well as questions dealing with methods. The results have been extremely gratifying. There is no question in the minds of any of the members of the department but that the meetings have resulted in co-operation, enthusiasm and accomplishment of results, which under old methods of organization, would have seemed impossible. Among the matters which have been taken up by the department are the following:

Consideration of courses and establishment of new courses including: (a) courses leading to a degree, (b) topical courses.

Two new courses leading to a degree have been established; namely, the four years' course in industrial engineering and the four years' course for teachers of manual training.

New topical courses have been introduced as follows: furniture design and construction, painting, pipe-fitting, plumbing, sheet-metal work, time and motion study, lecture and recitation courses in machine-shop methods, in foundry and pattern shop methods, in factory accounting, factory economics and factory planning.

A canvass has been made by the department of schools in Pennsylvania teaching industrial training, manual training, vocational training and the trades; ascertaining their methods and facilities. The department is establishing a laboratory and museum of industrial education.

A committee of standards of the department determined the duties, responsibilities, authority, routine and teaching schedule of each member of the department, and has put them into writing and also in the form of a graphical chart.

The department has initiated coöperative extension work with the local school system.

We have introduced planning systems and detailed instruction cards into all of our shops.

We have established an apprenticeship system.

We have developed our construction shops on a commercial and self-sustaining basis.

Among other matters taken up by the department and carried through to a successful finish are the following:

Establishment of departmental accounts on a double entry system.

Reviewing of recently published books bearing on subjects taught by the department.

Selection of books to be purchased and magazine subscriptions.

Distribution of expenses and allotment of fees.

Arrangement of equipment, of offices, files, desks, etc.

Alterations in lighting and power transmission systems.

Records of grades, absences and departmental regulations as to excuses from work and how it is to be made up.

Continuous inventory of stores and equipment, together with proper depreciation charges.

First aid to the injured.

Methods of teaching manual work, including: comparison of French, German, Russian and Swedish methods as well as methods in vogue in various American schools.

Kinds of shop work acceptable for entrance requirements.

Schedules of instructors; subjects and rooms.

Use of equipment by students outside of class time.

Lectures by visitors.

Maintenance and repairs to equipment.

Summer school courses for teachers to be offered by the department.

Standardizing, filing and indexing of drawings, catalogs and other memoranda for reference.

In this outline of the work accomplished at our department meetings and in my discussion on the results of experience in

teaching scientific shop management† I have outlined some definite and concrete accomplishments. In view of the above results attained it may not be out of place to add a few thoughts and suggestions to accompany the many others which have been made in the direction of furthering academic efficiency.

I believe there is a splendid opportunity in the colleges and universities for work in providing means for attaining higher efficiency by the individual instructor and for the development of loyalty and enthusiasm among members of the instructing force by systematic investigation and resultant action.

A systematic canvass made of all members of the instructing force in which each member would be asked just what is needed in his work to make him more efficient, and from each department and sub-department head as to what is needed to make him and the respective members of the teaching force under his jurisdiction more efficient, would if carried out in the proper spirit result in the accumulation of many suggestions. Some of these suggestions would be impracticable; some of them would be negative; but it is reasonably certain that there is a sufficient number of members in every teaching force with sane and positive constructive ideas for betterment, to guarantee that such a canvass would result in the securing of many ideas possible to carry out.

Talking from the point of view of a man who has spent a goodly number of years in commercial work and has seen capable men develop in the employ of large corporations, it is my opinion that few educational institutions are inefficient because of insufficient working hours or an insufficiently hard day's task demanded of the instructor. In industrial work men of the mental calibre of college instructors are provided far more help in the way of stenographers, clerks and draftsmen than is provided in colleges. In industry, a department head is encouraged to avail himself of whatever help is needed

† PROCEEDINGS, Vol. XIX., p. 153.

in the way of stenographers, clerks and draftsmen to make him a more effective producer. In practically every college in the United States the individual instructor must be his own stenographer, keep his own records, and do his own drafting, thus reducing his productivity and efficiency in his specialty from twenty to eighty per cent. In practically every college in the United States, department heads are insufficiently provided with stenographic, clerical and drafting help and must make negotiations with administrative officers for the loan of such help from their offices which have also usually an insufficient supply of it.

In very few colleges in the United States are individual instructors provided with private study rooms where they can study free from interruptions at certain definite periods. In attempting to introduce commercial efficiency some governing boards and administrative authorities require instructors to be at their desks during college hours. Such a requirement if accompanied by private study-rooms would be no hardship and would be welcomed by most teachers, as it would tend to shorten the necessary night work which must be done by every teacher, no matter how competent, in the preparation of his next day's work. This constant night work by all capable teachers, much of which must be done after social functions and night meetings of faculties and committees, is usually not realized by critics outside the educational field.

At the Pennsylvania Railroad Company's School for Apprentices at Altoona there are three teachers. These teachers are provided the entire daily services of a man who acts as clerk and stenographer. As a result the instruction papers, notes, references, records, etc., are in excellent order. If the industries consider it worth while to do away with avoidable fatigue and also with clerical work by teachers not trained in that direction, why should not educational institutions?

Are educational institutions systematically providing for the development of the individual instructor so that he may see more efficient methods and himself become more efficient? So far as concerns visits to other institutions they are not.

While engaged in industrial work I have frequently had occasion to show methods of the establishments with which I was connected, to engineers, superintendents, foremen, and cost department clerks who were sent out on visiting trips by other establishments for the purpose of acquainting them with the methods of other companies. To some extent such visits are made by members of college teaching staffs. However, they are usually made by deans or heads of departments and generally only on such occasions as the establishment of a new laboratory or the equipping of a new building. Such trips are seldom instituted and authorized for teachers in the ranks to be taken at times when the work is in active progress at the institution visited.

In addition to the systematic inquiry into means for development of individual efficiency, I would recommend a similar systematic canvass as to means for development of loyalty. Systematic and continuous efforts must be made to make the individual teacher's work inspiring and to get each man interested in his work. The system of promotion must be such as to afford numerous examples whereby ambition may be preserved. Fair play for all and the avoidance of sharp practices in dealing with employees have been recognized as vital principles in developing loyalty in the industries, and these same principles should prevail in all educational organizations. The individual teacher should be encouraged to undertake tasks of public service, to do research work, consistent with his teaching duties, and to write papers over his own signature. The progressive department head will realize that such encouragement of the individual teacher will tend to strengthen his department and add to the prestige of the department head. Social recognition, graciously accorded to the individual teacher by the department head in introducing him and his work to visitors on public and semi-public occasions, will do much to develop loyalty.

I believe the foregoing phases of academic efficiency are worthy of more attention than has been accorded them in the past.

In my discussion on the results of experience in teaching scientific management I dwelt particularly on a single phase of our four years' course in industrial engineering, namely, the class in machine shop time study. We have already graduated three classes in our four years' course, and a brief outline of the classes peculiar to this course may be helpful. The course is identical with the other engineering courses in the freshman and first semester of the sophomore year. In the second semester of the sophomore year a lecture and recitation course is introduced on foundry and pattern shop organization and methods. In the junior year classes are introduced in machine shop organization and methods, a course in machine shop time study and English economic history in the first semester. In the second semester manufacturing accounts and factory economics are taken up as well as American economic history and logic. In the first semester of the senior year, factory economics is continued with especial attention to scientific management. Principles of economics, labor problems, corporations and finance, and also psychology are taken up this semester. In the second semester of the senior year a designing room course in factory planning is taken up, also contracts and specifications, a continuation of corporations and finance, also an option as to political parties, railroad economics, or money and banking.

The mathematics, science and language work is identical with that in all our other engineering courses, while the machine design, heat engineering, electrical engineering, and experimental engineering may be said to represent about as much electrical engineering as is given to mechanical engineering students and about as much mechanical engineering as is given to electrical engineering students.

Our four years' course in industrial engineering is a decidedly different training in scientific management from a one or two hours' per week class in which an attempt is made to combine theory of accounts, contracts and specifications, cost accounting and scientific management, using a single text for the entire combination.

ACADEMIC EFFICIENCY.

BY WILLIAM KENT,

Consulting Engineer, Montclair, N. J.

About ten years ago I was asked by the president and general manager of a large manufacturing corporation to advise him how to improve the performance of his boiler house. During the previous winter it was pushed to its utmost to deliver enough steam to run the engines and to keep the buildings warm, and the next winter, on account of extensions to the factory and increased output, the demand for steam would be still greater. Before beginning my work the president told me something of the history of the company, and of how he came to be the general manager. It had grown in fifty years from a small concern to a large one, occupying several blocks of ground. The business was the manufacture of a variety of shelf hardware. He had for several years been a director and the manager of the sales department, and on the death of the former factory manager the directors insisted on his taking the place, although as he said he knew nothing about running a factory. He started in to learn how by calling in the best outside expert advice available. He was paying \$10,000 for a year's services of a highly skilled expert in machinery, jigs, and methods of manufacturing, who was making a revolution in the shop, which amply justified the high price paid for his services. This man said he knew nothing about boilers, and therefore I was called in to tackle the boiler problem. Incidentally the president told me that the catalogue of the products made by the concern contained 14,000 items, each of which involved patterns, jigs, templates, storage, book-keeping, records and correspondence. Probably half of these items were either obsolete or in very small demand, and another large fraction were unprofitable to handle. Another \$10,000 might have been properly spent in

making a selection of which of the 14,000 items should be abandoned and in printing a new catalogue.

In regard to the boilers, the president told me I could get all information available from two men, the superintendent of the factory and the chief engineer, who were at loggerheads. One had told the president one story about the boilers, and the other an opposite story, and he did not know which one to believe. He called the superintendent into the office to tell me his story, and, dismissing him, called in the engineer who told me the other story. I then had the engineer take me through the whole factory, including the power plant. On my return to the office I told the president that the engineer had told the facts, and that the superintendent had not because he was ignorant; he knew nothing about a power plant and never would know, for his bump of conceit was too great to permit of his learning. I reported further that the trouble from lack of steam was not the fault of the boilers—there were about 25 of them, crowding the boiler house to its capacity, and there was no available land for an addition to it—they were making as much steam as they should be called on to make with due regard to economy of fuel; but the trouble was entirely owing to the great waste of steam throughout the factory in winter time. Live steam was used for heating, and numerous traps were wasting both steam and hot water. As a result of my investigation an exhaust-steam heating system was installed, and that stopped all complaints of the insufficient supply of steam.

This long story about a factory may seem to have nothing to do with academic efficiency, but there are several points of resemblance between its condition and that of some educational establishments. They, like it, are suffering from inefficient management continued through a long period of years; they have too many items in their catalogue; heads of departments at loggerheads; a board of directors who are capitalists, but who know nothing of the details of the business they are supposed to direct; a president and general manager who is well versed in the advertising part of the business, but

knows nothing of the best ways of producing its product. The factory, however, has two points of difference from and advantages over the college. (1) The competition of its rivals forces it to improve its methods, while the college has no such stimulus to improvement. (2) The manager of the factory referred to, knows that he knows nothing about the best way of running a factory and therefore calls in outside expert assistance, the manager of the college thinks he knows it all, and therefore has no need of advice.

I said some educational establishments, not all. There are others, and this brings me to another story. It is about a university.

A certain large university more than twenty-five years ago had an engineering college that was already suffering from dry rot, although it was only about ten years old. It had a good location, excellent buildings and equipment, and ample funds, yet the college had lost prestige, and the number of students was decreasing. The president of the university knew nothing about engineering education, but he was wise enough not to pretend to know anything about it. He asked half a dozen or more consulting engineers and engineering professors to visit the college and independently to give him written reports as to what ought to be done to improve it. I was one of the visitors. I found that the college was divided into two independent departments, one theoretical and the other practical, each presided over by a professor who was responsible only to the president. I spent a morning with one of these professors and an afternoon with the other. Each told a tale of woe, about the utter worthlessness and total depravity of the other man. I advised the dismissal of both, and the appointment of a man who was big enough to be the head of the whole college. Some months were spent by the president of the university in getting these reports and in interviewing different experts, including men whose names had been suggested as qualified for the position. He selected the right man, gave him full authority, approved his every request, and the trustees gave him everything he asked for in

the way of competent assistants and additional equipment. The theoretical professor resigned, and the practical one gracefully subsided into a minor subordinate position, where he gave no trouble. The college grew with great rapidity. In ten years it was in the front rank of the engineering colleges of the world, which position it still holds.

Note the points of similarity between the factory and the university as related in these two stories. Each was suffering from inefficient management, each had a president who was ignorant of the details of the business, but who was conscious of his ignorance and was willing to take advice from outside. In each case the advice was taken, with the best possible results.

My subject is entitled Academic Efficiency. I use this short term merely because it has been used before to mean the efficiency of educational methods, and it may be necessary to explain that the word "academic" here means relating to an academy or educational establishment, and not, as it sometimes means, "unreal" or "unpractical." The word efficiency is often used with different meanings. Dr. Eliot, ex-president of Harvard University, in his little book on "Education for Efficiency" defines it as "effective power for work and service during a healthy and active life," and he says "national education will be effective in proportion as it secures in the masses the development of this power and its application in infinitely various forms to the national industries and the national service." The engineer uses a more restricted and technical definition, the quotient of output divided by input, or the relation or ratio of the result achieved to the effort in obtaining it. Mr. Harrington Emerson objects to this definition as insufficient in its not including an equitable standard of achievement or output as one of its factors, and defines efficiency as the "relation between an equitable standard and an actual achievement," or "the relation between what is and what could be."

Strictly speaking, the engineer's definition is limited to cases in which both the input and the output may be

measured in the same unit, or in units that are convertible one into the other, such as foot-pounds and heat-units, but it is a convenient definition for many cases in which neither the whole output nor the whole input are capable of accurate measurement in similar terms. For example,

We spend or give:

We get or gain:

Input.

Output.

Time,
Money or raw material,
Physical labor,
Mental labor,
Nervous energy,
Health,
Wear and tear of machinery.

Money or saleable goods,
Health,
Recreation,
Education,
Satisfaction.

If we take the engineers' definition expanded in this way so as to include in the input every conceivable kind of expenditure and in the output every conceivable kind of achievement, it will apply to every activity of man. The efficiency while it cannot be stated in figures, as a percentage, is measured by the value of the output in relation to the input or expenditure. Thus a business man may spend every one of the items listed under the head of input, and measured by a money standard the result may show a high efficiency, but measured by a broader standard, in which the result as to health is a negative quantity, it is most inefficient. Then if he takes to playing golf he may spend time, money and physical labor, and gain health: The efficiency by the money standard is zero, but by the broader standard, including health, recreation and satisfaction, he may consider that the efficiency of the operation is 100 per cent.

A college spends all the items listed under "input." Its efficiency is zero from the money standard, for its business is not to make money, and may be high or low measured in the other items listed under output. By Mr. Emerson's definition, the relation of an equitable standard to the actual achievement, or the relation between what is and what could

be, we compare the actual output in health, recreation, education and satisfaction, with what might be realized under the best possible conditions of system and management. Are the results what they ought to be in kind, in quality or in quantity, and if they are not, what are the defects and how can they be remedied?

In the big factory of which the story has been told, the product included 14,000 items, many of which should have been abandoned, and much of the inefficiency was due to the factory's making products that should not have been made. When an efficiency expert begins his operations in a factory his first questions are: What kind of product is made? Why is it made? Why not abandon it if it is not profitable? The same questions might be asked of a college. The next set of questions covers the quality. Is the quality too highly refined and too costly, so that its market is limited? Is it too common and cheap, so that it has to be brought into competition with the poorest goods on the market? Is it out of date and unfashionable? Is the quality what it ought to be, and if not what are the reasons, and how can it be improved? Surely these questions may be asked of a college, and it is the general belief that the answers would not be complimentary to the college. There are serious defects in the quality of the college product.

Next come questions as to quantity. Is the factory turning out too much of one kind of goods, so that the market is glutted and the price too low? Is it turning out too little, so that it is not doing as much business as it might do? Is it turning out too much of one kind and not enough of another; and if so, what changes should be made so as to establish a proper balance? Is the college overcrowding the professions with men who are not needed in them? Is it failing to supply the demand for the kind of men who are needed? The common opinion is that both of these questions must be answered in the affirmative. The last report of the Carnegie Foundation for the Advancement of Teaching says, "In almost every state of the Union there are more colleges in name than the

country needs or can afford. They have been started without much regard to the ultimate educational demands—weak and often superfluous colleges. In many cases their existence makes impossible that of good high schools which would far better serve the educational interests of the community.”

After these questions of kind, quality, and quantity of product are considered, then comes the question of cost per unit of product and of possible methods of reducing that cost. In the factory the solution of these questions is one of great difficulty and complexity. It includes the items of location, buildings, machinery, system of organization, functional foremanship, statistics, accounting, planning of work, routing it through the shop, methods of payment of wages, keeping high-priced men only on high-priced work and finally time-study resolved into its elements, that is motion-study. I quote from Frank B. Gilbreth's new book on Motion Study:

“There is no waste of any kind in the world that equals the waste from needless, ill-directed, and ineffective motions. . . . Tremendous savings are possible in the work of everybody—they are not for one class, they are not for the trades only; they are for the officers, the schools, the colleges, the stores, the household, and the farms. . . . It is obvious that these improvements must and will come in time. But there is inestimable loss in every hour of delay. The waste of energy of the workers in the industries today is pitiful. . . . In the meantime, while we are waiting for the politicians and educators to realize the importance of this subject and to create the bureaus and societies to undertake and complete the work, we need not be idle. There is work in abundance to be done. Motion study must be applied to all the industries. Our trade schools and engineering colleges can:

- “1. Observe the best work of the best workers.
- “2. Photograph the methods used.
- “3. Record the methods used.
- “4. Record outputs.
- “5. Record costs.
- “6. Deduce laws.
- “7. Establish laboratories ‘for trying out laws.’
- “8. Embody laws in instructions.
- “9. Publish bulletins.
- “10. Coöperate to spread results and to train the rising generation.”

Mr. Gilbreth refers to motion-study of the industries that are producing material wealth, but his words may be applied to the industry of educating men and women, that is to the schools and colleges.

The methods of reducing the cost per unit of product in industrial concerns have now been reduced to a science by the management experts, Taylor, Gantt, Emerson, Parkhurst and others. In educational circles, only the merest beginning has been made. Bulletin No. 5 of the Carnegie Foundation for the Advancement of Teaching, a quarto pamphlet of 134 pages, entitled "Academic and Industrial Efficiency," contains a report by Morris Llewellyn Cooke of the investigation of the department of physics of eight different colleges or universities. Mr. Cooke has had several years' experience as expert on management of industrial works, and is now Director of Public Works of the city of Philadelphia. His report is only a preliminary one, and covers little more than a statistical investigation of the cost of instruction in physics per student-hour, and some observations on methods of administration, and on the economical use of buildings and of the time of the professors and instructors, in all of which he found great differences. The total cost of physics per student-hour at Harvard was \$1.08 and at Wisconsin \$0.60. Of these totals the interest on plant and equipment and administrative expense account is \$0.53 at Harvard, and \$0.18 at Wisconsin. There are differences in the colleges which are far more important, however, than those that can be expressed in dollars and cents. For example, Mr. Cooke found one in which the professors showed the heartiest interest in the progress of each individual student, and another in which "every time the students were mentioned, there were evidences that the teachers had in mind the students' scholarly inferiority and backwardness."

The cost per student-hour for any subject may be obtained as in Mr. Cooke's investigation. It will be a far larger task to determine the efficiency of the student-hour—that is what return in valuable education the student gets for the expendi-

ture of the thousands of student-hours that he spends in college. We have as yet no standards of measurement by which educational efficiency can be satisfactorily measured, but it cannot be doubted that some day such standards will be found, when well qualified experts are employed to find them. For a method of obtaining such a standard in English composition, see the writer's paper in *Proceedings of the Society for the Promotion of Engineering Education* in 1907 on "An Experiment in Teaching English to Freshmen in a University."

Efficiency, according to the engineers' definition, is the relation of output to input, or the relation of the result to the effort and cost expended in achieving it. From the college student's standpoint, the input is four years of time and say \$2,000 to \$4,000 in money. The output is what he receives for that amount of time and money. Let us put what he receives in tabular form under two heads, life and study.

Life	{	Acquaintance.	Study	{	Cultural	{	Disciplinary.		
		Companionship.			Informational.				
		Fraternity.			Technical	{	Foundations of		
		Social Activity.					Science and Art.		
		Athletics.			Vocational	{	Relating directly		
		Reading.					to life work.		
		Leisure.				{	Curious	{	Non-useful or
		Travel.							dilettante.
Moral Uplift.									

How many hours out of the 24 in a day are student-hours, and how many are devoted to so-called college life? Is his time properly divided between the activities of life and study? Of the student-hours is there the proper balance between the cultural and the other branches? How and by whom is this balance determined? Which of the courses are prescribed and which are elective, and why? What text-books are used, and why? Are particular courses taught by the text-book and recitation method, by the lecture and note-book method, by the problem method, or by the laboratory method? Is each teacher free to use his own method or is the method determined by a department head or committee or by other

authority? What experimental pedagogical work has been done to discover the relative efficiency of different methods? What are the results of such experiments? Have they been reduced to statistical form and published? What is the administration doing to improve educational efficiency? Is there any method employed to measure the relative efficiency of different teachers, or of the same teacher in different years or when using different methods? How are the tenures of office, promotion, salary, etc., determined? How are poor teachers got rid of or transferred to other positions in which they may be more efficient? What is the organization of the college, and what are the efficiencies of the board of trustees, the president, and the heads of departments? If an investigator like Mr. Cooke, or preferably a commission of investigators, were to report to the Carnegie Foundation answers to these questions after a year's examination of a dozen or more institutions of learning, it is safe to say that an appalling lack of efficiency would be disclosed. The commission would find every grade of goodness and of badness in the teaching staff, teachers generally overworked, underpaid and dissatisfied and on the lookout for positions elsewhere. It would find self-perpetuating boards of trustees responsible to nobody, individual trustees chosen not for any educational qualification, but solely because they are men of wealth and influence; presidents chosen through personal or political favoritism, whose ideas of education are those of the middle ages, and whose methods of government are those of the tyrant. It would find the conditions mentioned by President Benton, of the University of Vermont, in his inaugural address, 1911, namely, the election of new members of the faculty dependent entirely on the dictum of the president, "the administrative office a veritable cesspool where unpleasant experiences are deposited," "a coterie of professors painfully sycophantic in the presence of their 'lord and master' and bitterly denunciatory of him when left to themselves," "reprehensible hypocrisy by those who teach," etc. President Benton seems to be unaware of the fact that the sycophancy and hypocrisy

which he thus bewails are the inevitable results of government by an ignorant despot, and that they can be done away with only by a radical change in the system of government. I do not wish to be understood as believing that the conditions thus described are universal. There are many institutions in which there is no autocratic government, and in which the government approaches in some respect to democratic ideals, where free speech is possible, where merit is recognized and rewarded, and where the teaching methods are constantly being improved. Here and there we find evidences of attempts to find the best methods, and of new experiments in education whose results are very promising, for example, Professor Franklin's improvement at Lehigh in the method of teaching laboratory physics; the examination of the English teaching in different technical schools by Professor Earle, of Tufts College; the introduction of the preceptorial system at Princeton; Professor Schneider's coöperative system in Cincinnati; the university extension work at Wisconsin; the investigation by a committee of the Society of American Bacteriologists of the teaching of microbiology; and Dr. Rumely's experimental preparatory school at Interlaken, Ind.

Mr. Harrington Emerson has written a book entitled "The Twelve Principles of Efficiency." He wrote it with especial reference to the efficiency of manufacturing establishments, but the principles may be applied to educational institutions. They are the following: (1) Clearly defined ideals. (2) Common sense. (3) Competent counsel. (4) Discipline. (5) The fair deal. (6) Reliable, immediate and exact records. (7) Despatching. (8) Standards and schedules. (9) Standardized conditions. (10) Standardized operations. (11) Written standard practice instructions. (12) Efficiency reward. The investigating committee might use this list of twelve principles of efficiency in its examination of the colleges and find to what extent they are in operation.

Suppose that the Carnegie Foundation were to have an investigation made such as is here suggested, what good would it do? The same good that Mr. Cooke's investigation of the

cost of the student-hour did, and something more. It would call public attention to the subject, and might lead some universities to reform some of their methods. It would reveal how bad things are, which is the first step toward reform. The report would be denounced as Mr. Cooke's has been, by college presidents and by editorial writers of conservative ways of thinking, as utterly subversive of all the ancient educational ideals, and involving "a gross and fundamental error." But it would set men thinking. It would show them that some universities and colleges and some educational methods are better than others, and give the public some knowledge which would enable them to select the best colleges, and some educators of a progressive turn of mind the information they are looking for in regard to methods.

The best possible result of such a report, however, might be that it might induce some multi-millionaire to think that he had a duty to perform in helping to improve the efficiency of educational methods, by contributing the funds that would be required to carry on an educational experiment similar in extent to the experiments carried on by Mr. F. W. Taylor in the Midvale and Bethlehem Steel Works. It required more than twenty years of labor and the expenditure of some hundreds of thousands of dollars to carry on his experiments on tool steel, which have revolutionized machine-shop practice, and on scientific management, which bids fair to cause a far more important revolution in all our industrial systems. Mr. Taylor's system of management cannot be adopted without many modifications by an educational institution, but his system of experimentation can be. It is simply the careful collection of all the facts by an expert, their study by mathematical methods, the making of experiments to get more facts, their further study, and careful reasoning to arrive at correct conclusions. It takes years of time, thousands of dollars of money, and can only be undertaken, with any probability of reaching valuable results, by a scientific expert who is entirely unhampered by old traditions. The motto of the conservative is "whatever is, is right," that of the scientific expert

is, "whatever is, is apt to be wrong; I am going to test it and find out whether it is right or wrong."

Here is the outline of an educational experiment to take ten years of time and cost half a million of dollars—less money by the way than one second-class university has spent on its equipment for athletics within a few years, and less than has been paid by some millionaires for a couple of paintings.

Appoint a commission of five well educated men who are not connected with any educational institution, say a minister, a doctor, a farmer, a merchant and an engineer, to secure a wide diversity in points of view. Pay them \$5,000 a year each for the first year, and a smaller sum in succeeding years, when their time will not be fully occupied, and provide them with an office, stenographer and clerk, and funds for traveling expenses. Let them spend a preliminary year in investigating actual educational conditions in this country, collecting facts, statistics and expert opinions, on which they should prepare a report. They should also report their opinion on what should be the course of education of a boy between the ages of 14 and 16, if he intends to go to work in the mechanical trades or in commerce at the age of 16, also what should be the course from 14 to 18 (1) if he intends to go to work at 18, (2) if he intends to enter a general college, (3) if he intends to enter a technical school. The second year the experiment is to be begun. Select a hundred boys who are ready to enter high school, of the majority of whom there is a reasonable probability that they will, if they prove fitted for it at 18, take a college course. Rent a preparatory school, or a portion of one, and have the boys taught, by selected teachers, in the courses laid down by the commission. Provide enough tutors or preceptors to insure that the education of the boys is properly supervised and that their time is not wasted. Continue their high school education, for as many of them as stay in school, for four years. During all their time the commissioners are to be studying methods of teaching, and methods of measuring the efficiency of teaching, preparing practical standards of examination, not merely to test the

memory of the scholars, as in ordinary examinations, but to test their mental and bodily powers. Find out not only what the boys know, as a mere act of memory, but what and how they think, and what they can actually do. Test not only the hundred boys, or as many of them as remain, but also boys in other high schools, by the same standards or by other standards that may be proposed by the high school teachers. Cultivate the same spirit of emulation for success in scholarship that now exists for success in the athletic field, but give them also enough athletics and other recreation to develop their bodies as well as their minds. Train them also in hygiene, in morals and in manners, to make them not only scholars but gentlemen.

During these four years the commissioners are also studying college administration, courses, methods of teaching, and efficiency, and determining standards of measurement of efficiency. When the boys are through their preparatory course of four years, send them to such colleges as have been selected for them, have them take the courses for which they are fitted, provide tutors for them, and watch their progress through the college, testing them by predetermined standards in comparison with other college students. At the end of the four-year college courses, the commission is to report on the whole eight years' experiment. It will be found that many mistakes have been made, but probably not so many as would be made in an ordinary eight-year course of high school and college. The success of the experiment is not to be judged by the success of these selected boys, but by the value of the information obtained and reported on by the commissioners as to the various methods of teaching and of college administration and by the acquirement of standards by which academic efficiency may be measured in the future.

During the whole of the eight years' experiment the boys should be required to keep a diary in which they record what seem to be the most important items concerning their education, and they should once a year present to the commissioners a written report of their progress, keeping a copy for their

own future use. Four years after they have graduated from college, when their minds are sufficiently mature, they should be asked to write critical reports of their educational career as it then appears to them. A study of these reports by the commission, which should be continued in existence for that purpose, would no doubt furnish fruitful ideas for further educational progress.

Cecil Rhodes did a noble work in establishing the foundation of the Rhodes Scholarship in Oxford. Andrew Carnegie has done a grand work in establishing the Carnegie Institute for Scientific Research and for the Advancement of Teaching. Equally grand will be the work of him who shall establish a foundation for the application of the methods of scientific management to the improvement of academic efficiency.

This proposed plan is merely a suggestion. There may be a better plan, but whatever it may be it will take years of hard work and a large sum of money to accomplish the desired results. It might be undertaken by the Carnegie Foundation for the Advancement of Teaching, by the Russell Sage Foundation, or by the government, but the funds of these foundations are probably already fully employed, and judging by the past non-activity of the government in educational matters it might take twenty years of agitation before Congress could be induced to make the necessary appropriation. The government has a department of agriculture which is making experiments for the farmer, to enable him to grow larger and better crops, a bureau of forestry which is trying to conserve our forests, a bureau of mines which is experimenting on improving the methods of mining and on the prevention of accidents. It has also a bureau of education, which publishes statistics of schools and colleges and some interesting papers on educational subjects, but which has never investigated academic efficiency or carried on an educational experiment. All educational reforms in this country have been originated by individual philanthropists or by individual universities. They do not come about by normal process of evolution in the educational world or by govern-

mental action, with perhaps a single exception, the Morrill Land Grant Act of 1862, just fifty years ago. We therefore must look for a millionaire philanthropist to begin the great educational experiment which will lead to improving the methods of training our future citizens.

Our modern educational literature, addresses of college presidents and school superintendents, proceedings of societies, etc., all show the prevailing consensus of opinion that there is something seriously wrong with our whole educational system, and that instead of getting better it is constantly tending to grow worse. There exists also a great amount of ultra-conservatism and of mental inertia relating to the subject. It is high time that something practical be done in the way of reform.

OPERATING ENGINEERING SCHOOLS UNDER SCIENTIFIC MANAGEMENT.

BY H. WADE HIBBARD,

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Privileged by an assignment from Chairman Gilbreth of this meeting on academic efficiency to present an opinion upon operating engineering schools under scientific management, the writer will attempt to suggest an analysis such as might be made by an efficiency engineer employed to investigate an industrial business.

A teacher who has had any experience in the improvement of industrial efficiency must be keenly conscious of the special difficulties of this problem. The mere statement that the raw material is an unstandardized boy and the product is an improved man even less standardized, instead of pig iron and a turret lathe, should hint at one unsurmountable difficulty. Mr. Pritchett's introduction to Engineer Cooke's report to the Carnegie Foundation for the Advancement of Teaching recognizes that "scholarly and spiritual leadership is the highest quality of college efficiency and the one most necessary to attain." The total absence as yet of any unit for measuring the efficiency of men engaged in teaching and research increases the difficulty. The writer, in a recent discussion with President Hill, of the University of Missouri, must agree with him that "the best way to be conceived for killing the entire spirit of research would be to attempt to estimate a man's value in terms of the quantity of his output. It would tend to make still more mechanical the work of men who ought not to be mechanical at all, for teaching and research are matters that cannot be reduced to mechanism."

Scientific management of shops finds a large field in transferring to the more intelligent managers most of the brain

work which was but indifferently performed by the far less mentally capable individual operatives. The college difference is obvious.

To enumerate all the differences is a function of the destructive critic, the doubter and the pessimist. The constructive mind, overlooking none of the difficulties, but giving careful consideration to all, would better attempt to discover the many applications of the principles of scientific management to engineering schools. To the efficiency engineer, introducing scientific management in the industries, nothing is more common than to hear an owner say that his plant stands alone for its problems, or that a department presents peculiar difficulties which must exempt it from the proposed line of improvements.

Hopeful indications are that engineering teachers to a man are desirous of adopting those innovations which probably will be improvements; that some of the most surprising results of scientific management have appeared in the very offices of the managers; that everywhere the industries are recognizing the necessity of bringing the human side of production up to the high degree of excellence already attained by the machinery side; that the preceding has its counterpart in the new courses given to engineering students upon the principles of man-management or scientific discipline; and that the industrial world is coming more and more to feel that all work is done under certain broad principles, whose application to one industry is very little different from the application to any other.

Colleges are not dreading change, but the strife by which some seek to bring it about. College professors may well scrutinize changes advocated by business men, lest they be without sufficient respect for the verdict of time. Ordinary business thinks in short cycles, without much regard to what follows; a university is not a weather vane, but stands for what has proved wise progress through the years. Engineering professors have always sought to profit by suggestions from the outside world, are most frequently recruited from

that world, often return to it for a summer or longer, and believe heartily that only good can come to an organization when a friendly hand turns the public's searchlight upon its resources, aims and methods. That the hand is non-academic is well, for in every line of work the outsider may see conspicuously the wastes to which slow growth or long custom have blinded the eyes of the insider.

Management is the science and art of accomplishing a given end with economy of means. A science is a systematic and orderly arrangement of special knowledge; an art is the actual performance of something. The art is the doing; the science is the knowing why and how. If "man's greatest study is the study of man," then the education of an engineering student is subject matter for the application of management of the highest type.

The philosophy of management is having as many definitions today as the term philosophy itself. Though philosophy is the most ancient of sciences, yet Webster gives it at least twelve definitions. It reminds one of the many definitions of the second law of thermodynamics. Taylor, who for thirty years has been led by the scientific spirit of inquiry to investigate management of men, calls scientific management a certain combination of elements which have existed in the past, namely, old knowledge so collected, analyzed, grouped, and classified into laws and rules that it constitutes a science, accompanied by a complete change in the mental attitude of the working-man as well as of the manager, toward each other, and toward their respective duties and responsibilities; also a new division of the duties between the two sides, and intimate, friendly coöperation to an extent that is impossible under the philosophy of the old management. The managers assume the burden of gathering all the traditional knowledge which in the past has been possessed by the workmen, and then of classifying, tabulating and reducing this knowledge to rules, laws and formulas.

Taylor further summarizes this whole combination as follows:

1. Science, not rule of thumb.
2. Harmony, not discord.
3. Coöperation, not individualism.
4. Maximum output, in place of restricted output.
5. The development of each man to his greatest efficiency and prosperity.

The efficiency engineer has two lines of work, the analytical and the synthetic or creative. The first furnishes reliable and intimate knowledge of affairs as they are. It is always a delight to see the appearance of hidden matters as the result of minute analysis. Nothing is too small or too broad for investigation, the microscope or the telescope being used as needed.

The second line, based upon the first, creates the improvements. Some of the creative may accompany the analysis from the first, but the far-reaching improvements obviously come later.

A quotation from C. B. Going may conduce to a better appreciation of the service of the efficiency expert to the school of engineering. Going says, "He deals with machinery; but not so much with its design, construction or abstract economy, as with selection, arrangement, installation, operation and maintenance, and the influence which each of these points or all together may exert upon the total cost of the output."

"He deals with materials; but not so much with their mechanical and physical constants, which are strictly technical considerations, as with their proper selection, their standardization, custody, transportation and manipulation."

"He deals very largely with methods; but the methods with which he is particularly concerned are methods of performing work, of securing high efficiency in machinery and men, of handling materials and cost per unit handled, of keeping track of work-in-progress and graphing the situation so that the manager may have an instant controlling view of all, of recording times and costs so that the efficiency of the performance may be compared with predetermined standards, of

detecting causes of low efficiency or poor economy and applying the necessary remedies."

"He deals with management, that is, with the executive direction of the whole organization."

"He deals with men themselves and with those psychological influences which concern their thoughts, purposes and emotions, and stimulate their ambition, enlist their coöperation and insure their most effective work."

"He deals with markets, with the economic laws affecting them and the mode of creating, enlarging and controlling them."

It may be suggested that the following phases of scientific management are applicable to the operation of an engineering school. This paper is not offered as the final solution, but as a modest feeling towards the possible end. It is in part based upon our two years of experience in teaching scientific shop management to senior mechanicals at the University of Missouri, upon which a paper was read to this Society one year ago.

Scientific management requires:

I. A complete analysis and criticism of the organization, with graphic representation, showing lines of responsibility, with extent and limitations of duties.

II. Analysis of the financial administration.

III. Analysis of the equipment, including buildings.

IV. Every act of man and machine to be investigated, and by minute scientific analysis its elements determined and its laws found.

- V. Decision as to how each act can best be done, together with the

VI. *Selection* of men fitted to do the work.

VII. *Training* of men so selected to do the work in the way determined to be the best, each man being developed to his greatest efficiency and prosperity.

VIII. By adequate supervision and proper incentive, ensure that the men *practice* the best methods *all the time*, securing and continuing maximum output.

IX. Team-work, without hampering a wise individualism.

X. Coöperation between managers and men.

XI. Building up of an advisory cabinet or staff, if the Emerson idea seems preferable and the old line officers are retained; or organizing functional foremanship, if the Taylor idea seems preferable.

XII. Delimiting the respective duties of officers and cabinet, or manager and functional foremen.

The above work seems vast and is vast. In the introduction of scientific management at a New England paper mill, 1,500 time studies were taken in the first three months and there were 18,000 time studies in one schedule report. A great national corporation having 22 plants and 300 miles of railway approached an efficiency engineer with a proposition to undertake the introduction of scientific management to be completed in fifteen years.

But in the engineering school as in the industrial plant, improvement ought to become apparent early in the application of a part of the above twelve requirements. In the paper mill, though six months were spent in the time study of the calender department, within three days the efficiency of the calendar machines was raised from 64 per cent. to 72 per cent. Emerson wants to show savings very soon after starting work in a plant. Shop efficiency can be raised from 60 per cent. to 90 per cent. without any personal incentive such as bonus payments, simply by making things "right" in standard or ideal materials, equipment and methods. Emerson outlines a dozen principles of efficiency, and only one is efficiency reward. If organized labor objects to the bonus system, an efficiency engineer may attain almost his entire improvement without introducing the reward. In the engineering school, only so much or so little, and at different speeds, of the above twelve requirements may be introduced as is deemed advisable.

How may the twelve requirements of this paper be applied to the university?

I. In making the analysis and criticism of the organization, beware of advocating a panacea or specific for all ills. Principles and ideals must constantly be kept prominent, while "systems" must vary with the conditions.

The form of organization of universities appears to be what is known to the efficiency engineer as "line" or unfunctionalized control, whether it be one-man power or committee power, and with many combinations. Sometimes the centralized control is on paper only, each different college and even a large department as physics being autonomous in control of its affairs, buildings, discipline, work of its faculty and curriculum.

The one-man power burdens the man with too many functions; committee control means compromises, and *they* leave business in such shape that it must be thrashed over again and often reversed; and departmental autonomy prevents solidarity of the university and coöperation between departments and allows abuses to continue.

To quote from Cooke. "The first great object of organization is to make each individual count for his maximum. Hence he must do those things for which he is best suited. Almost invariably under committee management is seen the spectacle of several men, experts in their own specialties, all simultaneously wasting precious time in deciding questions outside their own field, which could be better and far more quickly decided by a single expert, whose time may be worth less than that of any one of the committeemen. Modern industrial management seeks to relieve the head men of all possible routine, such as is the bulk of committee work, and so enables them to give their entire time to progress. At the same time, these heads are kept constantly informed, through carefully prepared and summarized 'exception' reports, as to all unusual matters of vital import.

"One-man and committee management should be replaced by functional or staff management, where the effort is made constantly to have each man perform those functions which he is best fitted to perform, and to prohibit him from inter-

fering in the performance of those functions about which he is not specially qualified to give an opinion. A man is thereby safeguarded in the performance of the highest kind of work he is competent to perform."

Starting with the board of trustees, it should determine the broad and general policies for the university, and leave the president alone in his executive function. "The world's experience has demonstrated the utter impracticability of doing executive work under the management of more than one man. Even in a partnership, one man will have absolute charge of production and another of finances and sales.

"Applied to the college, the work would be divided into 25 or 50 functions, in each of which some one person will be supreme, under the determined standards controlling him. This is quite different from 50 *positions*, the occupant of each having many functions to perform." The successful teacher or administrator will become known and hence valued, because his ability is as functionalized and definite as that of the research worker. A professor will gladly be relieved when a central agency or functioner is found to do certain work better than he. If a man feels weak in one function which he has to perform because of overlapping of duties, he can secure help from a specialist in that function. A professor will commonly be directed by several functional guides, but he in turn will not be upset by those who are almost ignorant of his work or duties.

I have listed 209 different activities of a professor. The high-priced presidents of great corporations would not dream of attempting to perform such a variety of functions. For present purposes, only 84 of these will be mentioned. The time available for the preparation of this paper has not permitted a careful analysis and grouping, consequently it is not made clear which duties are sufficiently related to be grouped under one functioner.

A professor's activities cover:

Teaching in
Lecture

Recitation
Laboratory

Drafting	and progress
Computation	Other engineering schools
Field work	Relations with the profession
Seminary	College catalog
Examinations on his own work	College and department circulars
Class discipline	Engineering experiment station
Friendship with students	Engineering bulletins
Breadth of culture	University extension
for professor, and	by correspondence
its encouragement for student	by centers
Research	Summer school
for professor	Advertising and public sentiment
for students	Student grades
Methods of student study	Grading methods
Student engineering society	Electives for engineers
Inspection tours	Schedules for classes
Foreign lecturers	Use of rooms
Summer positions	Lighting plans
Graduate positions	Supervision of teaching
Alumni list	Improvement of teachers
Employment bureau for alumni	Employment of new teachers
Registration	Acquaintance with foreign
Issuing stores	teachers
Issuing apparatus	Pedagogical progress
Laboratory deposits	Work in engineering professional
Control of student activities	societies
City moral cleanliness	Work in this Society
New apparatus	Writing
Needs	Problems of
Choice	Buildings
Markets	Grounds
Installation	Janitors
Regular supplies	Power house management
Repairs	Problems of
Repair shop	Heating
Inventory	Lighting
Deterioration	Water service
Out-of-dateness	Fire
New library books	Prevention
Use of library	Extinguishment
Catalog library	Bookkeeping
High school	Appropriations
Standards	Personal typewriting
Curricula	Hektographing
Engineering curricula	Lantern operation

The above are too many duties to make it probable that complete functioning can be applied. In a small industrial plant, one man may be given four fairly related functions—as a maximum. Such a man sharply defines his duties in each function, and he works for the time being as that one functional foreman. Then later on he works as another functional foreman. Much of the above professor's work can be grouped and functional men used. What cannot, might be left intact, and an expert staff assembled to guide it. Such changes should be slow, organizing first those functional activities which can be well done. It is generally best not to compel everybody to use a given functional agency when it is first started. "A purchasing agent, on assuming his duties, will find his time fully occupied in buying for those who are anxious to utilize his services. It is of importance that those who first come in contact shall be impressed with the efficiency and genuine helpfulness." Though professors are more intelligent than workmen and gang bosses, yet human nature is much the same everywhere.

II. Analysis of the financial administration.

The several colleges in a university, and the several teaching or research departments in the colleges, correspond to the several plants and manufacturing departments of a corporation. To each college and department should be charged its direct expense and share of "burden," "overhead" or general expense. The sum of these charges should cover the entire expenditures of the university. In this way only is it possible to know how costly is a college or department, in comparison with the *work* which it is doing. There is here not the least intimation that a very costly small department should be the one first discontinued. There may be many and overwhelming reasons why it should be retained. But it is right that the trustees should know the facts, and then act without ignorance.

The above carries the idea, of course, that when an annual appropriation is made to a department, based upon a pre-

viously prepared budget, every payment authorized by the department should be paid out of the department's fund. This puts emphasis for economical buying upon the teachers of the department.

Conversely, every department must be credited with its earnings.

Not a dollar should be spent without its passing through the university treasurer.

There should be printed and full and minute publicity given to all receipts and expenditures.

Careful distinction should be had between repairs and replacements versus new equipment.

The accounting department has three functions: auditing expenditures and vouchers, the up-to-the-day state of the business, costs as related to the most practicable and illuminating units. Where there is doubt as to the conditions or reasons for affairs, then accounting subdivides the financial data into the smallest units, for minute study, grouping as needed.

The results for study are put into graphical form for easy comparison, and into curves to show progress or retrogression. A graphical picture of statistics appeals simply and effectively to the eye, and thus carries its meaning instantly to the mind.

The eye is readier than the mind to read and compare differences in size or shape or slant. Columns of figures do not show differences so emphatically.

An official with many duties must economize his time by the use of graphical reports.

The higher the official, the more should his work lie in determining policies, leaving details and routine for his well-chosen subordinates to do. Curves show him tendencies and desirabilities, and enable him to choose policies.

Statistics, if plotted into curves, very early indicate tendencies. If these are objectionable, they can be corrected long before they would have become noticeable in columns of figures.

Everything has a cause. Often the cause is well hidden.

Until recent years, the cause was unknown of yellow and chagres fevers. The Panama canal is being built, not by engineers, but by the investigators of infected mosquitoes. The writer respectfully wonders why Mr. Cooke did not turn this graphics light upon the causes of statistics so faithfully gathered for his report to the Carnegie Foundation for the Advancement of Teaching.

Changes, improvements, extensions and added facilities show their relative values by their several inclinations in the curves affected.

Plotted information tends to prevent erratic expenditures and to insure steady improvement.

For the purchasing agent, the plotting of manufacturers' price lists often reveals irregularities. These are due sometimes to erratic loading of "burden," or to errors in cost keeping, or to local difficulties in workmanship when sizes pass a critical point. Such knowledge of price lists puts the purchasing agent in a more commanding position, from several points of view. He may even change an order, after of course consulting with the department issuing the requisition, for a size or make fully acceptable to the department.

Diagrams often catch the small things which run up the cost to departments, they prevent slackness and waste, and have been known even to catch theft.

Much use has been made of curves plotted with years as abscissæ, to prophesy the future and determine thus the financial requirements. Three years ago the New York Central Lines saved the expenditure of an already appropriated two million dollars by such a graphical prophesy.

When two curves of cause and effect are to be plotted, if the respective magnitudes of the units are extremely different, the plotting should be done upon cross section paper printed to the logarithmic scale, as explained in *Railway Age Gazette* for June 25, 1909. The plotting is just as simple as on ordinary paper, but tells the eye the facts much better.

As regards a purchasing department, the university is very different from the industrial world. This ought to be cor-

rected at once. A railroad buys a far more varied line of supplies than a university. The writer speaks from knowledge, for he has been a railway mechanical engineer in close contact with railway storekeeping. But just as in the railway, so the expert services of the professors will be used in buying things. The professor needs not to burden himself with the purchase of standard articles, in order to retain control of the purchase of a prism on which he is an expert.

The new purchasing agent will easily show great savings, by his larger quantities, by buying on a low market, by taking the discounts in quick payment of invoices, and in short by being an expert in his function. To quote briefly from several excellent pages in Ennis:

"The buyer must thoroughly know the markets which he enters. The trade papers, conference with other buyers, friendly relations with sellers, personal search into the history, conditions and prospects of industries with which he as a buyer comes in contact—all these help. He is a speculator, and he should be at least as well posted on the market for commodities in which he speculates as is the grain operator on weather conditions in the Northwest. If he is far-sighted, he will see many opportunities for advantage by accumulating staple stocks at times of low price. He must then use his expert knowledge to influence the requisitioning or storeroom departments to anticipate their requirements."

After all, the chief value of the purchasing department is not in the money saving, but in being able to secure (1) the articles best adapted to the purposes, (2) an increase in the speed of delivery, and (3) a greater convenience in making the purchase.

A stores department should be found profitable. Many departments use the same sorts of supplies, and by good reason time, money and convenience should be saved.

III. Analysis of equipment, including buildings.

A detailed study of the use of buildings, rooms and equipment will reveal many wastes. Cooke's report shows the brief use of costly rooms. There are three ways to improve on this.

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1. Publicity in the use of rooms, including the number of students accommodated.

2. A schedule of hours and rooms arranged by a functionalized officer each spring for the next year. This may be the duty of the registrar.

3. A rental price to be placed upon each room, and the rent to be paid by the departments using them. Conversely, when a building is given to a department by a special donor, the department may legitimately be paid rent by another department needing to use some of the rooms.

Occasionally a room may be used more continuously, hence more efficiently, by having an ante-room with rolling tables upon which lecture exhibits may be kept and then rolled out into the lecture room when needed.

Rooms used by the larger number of students should be on the ground floor.

Avoid the many useless store rooms, where junk accumulates. Keep junk cleaned out and sold or thrown away.

All rooms and equipment should be kept neat, for the good of the students.

An excellent plan is in operation at the University of Missouri, whereby junior and senior drafting rooms are put to extended use when no classes are scheduled. Each student has a desk and locked drawer. The room is kept locked, but each student has a key. These rooms thus become the "engineering offices" of the students. There they naturally meet after a lecture and discuss the subject, they make their laboratory and other problem computations, a teacher drops in informally, the rooms adjoin the "students welcomed" engineering library. One student is foreman in charge and responsible for order. Breakages, lost keys and missing lights are paid for out of the students' laboratory deposits. The Student Branch of the Am. Soc. of Mech. Engrs., after its twice-a-month engineering meeting in a lecture room, adjourns to the senior or junior mechanical drafting rooms for a light "feed" and social hour.

Ventilation is vital to efficiency, and in design or use of rooms should never be overlooked.

Buildings should be planned for right enlargement according to a pre-conceived plan.

Equipment and appliances of every sort must be inspected to determine whether of best available and in the best condition for use. If not in use, the sentiment that defers disposal, lest they might possibly come into use some day, should be sternly repressed. Sell or throw away the obsolete junk, for it is in the way and has to be kept clean.

IV. Every act of man and machine to be investigated, and by minute scientific analysis its elements determined and its laws found.

This means that the acts of the professor, as partially outlined in section I of this paper, and all the acts of the student, are to be subjected to the Motion Study of Gilbreth's book, modified to suit academic conditions. The engineering schools should coöperate in this work, parcelling out different portions to different schools. The benefits will begin soon after the research begins. An outline for some of this work has been made, but this paper is already getting too long.

The work will be vast, but it should not be felt as stunning. The Watertown Arsenal in Boston, though one of the most thoroughly "efficiencyized," has not yet put in many improvements clearly needed there and in use elsewhere.

V. Decision as to how each act can best be done.

Having listed, analyzed and investigated each act, the synthetic construction must follow. This was in part discussed immediately subsequent to Taylor's five summaries in this paper, in Goings's quotation. It is based on the belief that there is one best way to do any one thing, and that usually this best way can be determined by scientific methods. Every effort is made to discourage the practice of deciding matters on anyone's personal opinion. A most careful study is made of the facts above gathered. They are pored over and reasoned over, time and again. There must be a reason for every thing.

The investigator will probably be mixed and troubled, but after he has timed one job for thirty times, he will have acquired good judgment and will finally be able to decide upon each elementary motion and each elementary allowed time, which will be permitted to enter into the standard or ideal time and method for doing that job.

The standard act or "operation" of course means that there are standard conditions and standard equipment. These are to be provided for under the previous headings.

The best ways for doing all the acts mean a saving for the professor, student and university, of time, energy and money.

VI. *Selection of men fitted to do the work.*

There are in this matter two opposed opinions, with all the gradations which completely fill the middle ground. One group of efficiency engineers would lay down hard and high standards, and then hunt for men to measure up to them. The result would be a picked body of workers.

The other group would be more flexible, and by taking a body of workers as they found them, would highly educate those who had capacity for high achievement, but also improve and use those who could never hope to keep up with the leaders. It remains for the future to see which method will work out better with professors as the men to be improved or selected, and the students as the material. Functional foremanship may develop a bureau for the placing and exchange of teachers fit for a function. In the industries, it is certainly easier to find a functional foreman and easier to break him into his new position, than the old time military foreman trying to perform all functions.

VII. *Training of men so selected, to do the work in the way determined to be the best, each man being developed to his greatest efficiency and prosperity.*

To train a man, he must be put into possession of a knowledge of the best method you expect him to follow. Scientific management provides the workman with standard tools. There will need to be worked up standard lectures for the

younger teachers to use. A professor must not consider his own lecture notes and his teaching mechanisms as his own private "stock in trade." These standard lectures are to be found in the physics department of the University of Toronto. As there explained by the professor in charge, "All the members of the department use them as the basis of their lectures. Our men are made available for class work earlier. These notes, being available for our instructors, leave their time free to develop other and new lecture courses, or to carry on research."

Such standard lectures aid in a careful thinking out of a lecture, and when rightly used are harmless to desirable inspiration (not the "inspiration of the moment").

It may be best to buy such notes outright, or to engage new men with the understanding that part of their time is to be given to working up such standards.

It is of course to be well understood that this idea of standardizing is not to be applied to students in such a way as to enable them to avoid thinking out the personal and vital solution of the problems for themselves.

All the best methods of section V will be reduced to the form of complete instruction sheets for use later in teaching.

There will be expert instruction in teaching methods.

Committee meetings will be standardized, and so the wasted time cut out. All routine work will be done for the professor, such as mimeographing, issuing stores, taking of inventory, room scheduling, typewriting, etc. He will also be relieved from all the higher functions for which a better man can be found, leaving him free to develop his own function or specialty to the very highest degree of perfection free from interference. Every man will be in a place where he can best develop.

There will be a definite day of work, with more close application during the established hours, and then relaxation. Both professors and students will be obliged to rest one day in seven. The time studies in mental fatigue will have deter-

mined the class schedules for students and professors so that there will be proper rest intervals during the day.

VIII. By adequate supervision and proper incentive, ensure that the men *practice* the best methods all the time, securing and continuing maximum output.

A new central bureau will have as its function: Inspection. In the industries, it would be a silly sort of inspection to have the very piece workers, who planed or drilled the article, inspect it and pass it on to the stock room as perfect. So examinations will be given not by the teacher of the boys examined.

The entire scholastic record of a student will be taken, and every department will know what he is doing in all his other departments.

A proper discipline will require the same attendance at class and in the university as though the student were in an industrial organization, where one "cut" would bring a serious reprimand, and the second "cut" would probably cause him to lose his position.

Efficiency rewards will be arranged for speed with excellence upon such work as kinematic and thermodynamic problems.

There is need to get professors to work not harder, but more efficiently.

There is almost no "proper incentive" needed, for it is a body of employees made up of most intelligent owners. Each teacher is desirous of doing a full amount of work, yet does not want to spoil a loved course by being overworked in other courses or ways. The feeling of ownership of the university by the faculty workers decidedly obliterates one feature of need of application of a principle of scientific management. The point can best be illustrated by a quotation from the Pittsburgh paper of 1911* in which the writer was joint author. "Scientific management is not a natural outgrowth of systems or even of system. It is not an evolution. It is rather a

* Proceedings, Vol. XIX, p. 19.

reversion to type. A great industry under scientific management closely resembles in its essentials the small shop, in which the owner and his few men intimately connected with him were studying and working intelligently and harmoniously with a view to perfecting the operation. The unscientific large shop has a manager most distantly removed from a vital connection with the operation, and the latter is left to those unable to give it intelligent study."

An effective organization must stimulate by the force of example. Hence every man should have specific and visible individual duties, which all other men can see he performs well. The "dispatching" of the industries becomes here the assignment of work to teachers by the proper authority, after of course proper advice has been taken from staff specialist. If the department is operated under functional foremanship, the dispatching will be done by the expert whose function that duty is.

Every teacher must be made to feel a sense of personal proprietorship in the work for which he is chosen.

IX. Team work, without hampering a wise individualism.

The Cooke report recommends in every university a "general research board," whose duty it would be

(a) To organize the general policy of the institution in the matter of research,

(b) To bring about as much coöperation as possible between the departments,

(c) To correlate as much as possible research work going on in different sciences,

(d) To procure assistance for those needing it,

(e) To pass upon the expediency of undertaking any given project,

(f) And to keep constant track of the progress of work and of its cost.

The writer would like to add to duty (b) that the coöperation should extend to other universities, to include also the shipping of both apparatus and students to the places where they will fit best.

All teachers should keep closely in touch with each other, in office calls, walks, sports, clubs, and elsewhere.

There should be frequent (at least monthly) informal conferences of a small group of professors to discuss "progress policies" for the institution.

Understudies should be ready to fill any man's place at a moment's notice, should he be taken ill or be called elsewhere. The teacher should himself be training his own understudy.

One should never disparage a teacher when talking to another teacher, or to a student.

A teacher or officer with larger responsibilities should unload certain of his responsibilities upon other men, thus not only giving them the valuable training, but also releasing more of his time for consideration of the larger policies of future progress for the school or department.

Conversely, every man to whom responsibility is given should gladly assume his duty and make his decisions himself and accept whatever blame or credit may be his due, rather than try to shift his responsibility upon the man above him. It is his duty, nay privilege, to relieve the man above of all the work possible.

In introducing new plans, it should be remembered that evolution is safer than revolution, and that the new plan should be thought through to its results from every point of view.

For profiting by intimate colleague associations, one should analyze into elements the successes and failures of others, learning the efficiency beatitude "Blessed be the man which learneth from experience, but thrice blessed be he which learneth from the experience of others."

X. Coöperation between managers and men.

XI. Building up of an advisory cabinet or staff, if the Emerson principle seems preferable and the old line officers are retained; or organizing functional foremanship, if the Taylor principle seems preferable.

A suggestion is offered for a staff of experts for a university

president. These men may also be professors or administrative officers, but their primary duty should be as the president's aids. Their functions are as follows: alumni, buildings and grounds, department needs, discipline, equipment, finances, legislation in state, pedagogy, relations among the colleges and the departments, relations with other universities, research, selection of professors, student activities.

XII. Delimiting the respective duties of officers and cabinet, or manager and functional foreman.

Acknowledgment is made for extracts, sometimes condensed and without quotation marks, from the following authors on efficiency: Cooke, Emerson, Ennis, Evans, Gantt, Gilbreth, Going, Jacobs, Taylor.

In conclusion:

"Well, what of it?" Some one will say: many of the efficiency suggestions in this paper are minor, almost the non-essentials; that the teacher's ability to understand a student's difficulties, to lead him into right scientific methods, to stop teaching when a student has been taught enough, to *inspire*,—has not been touched upon nor greater efficiency pointed out.

To reply: the efficiency engineer, at work in an industrial plant, does not attempt to give fundamental brains to a manager and his subordinates. He does not give the inspiring soul to a superintendent. There are qualities of soul which the Creator alone gives to leaders in the industries and in teaching. The purpose of this paper is to show how an efficiency engineer might relieve a leader's soul from present handicaps, petty and huge, and enable it thus to work more efficiently.

May I join Mr. Cooke in full sympathy with the spiritual significance of university life, and with him quote from President Eliot: "Education for efficiency must not be materialistic, prosaic or utilitarian; it must be idealistic, humane and passionate, or it will not win its goal."

EFFICIENCY IN ENGINEERING EDUCATION.

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The principles of efficiency are definitely known. The following table compares the two most famous statements of them:

TAYLOR'S STATEMENT.	EMERSON'S STATEMENT.
The Four Elements of Scientific Management.	The Twelve Principles of Efficiency.
The development (by the management, not the workman) of the science of the work, with rigid rules for each motion of every man, and the perfection and standardization of all implements and working conditions.	Supernal Common Sense. Competent Guidance. Standardization of Conditions. Standardization of Operations. Determination of Standards.
The careful selection and subsequent training of the workers into first class men, and the elimination of all men who refuse or are unable to adopt the best methods.	Ideals. Discipline.
Bringing the first class workman and the science of the work together, through the constant help and watchfulness of the management, and through paying each man a large daily bonus for working fast and doing what he is told to do.	Fair Deal. Efficiency Reward. Immediate, Adequate and Reliable Records.
An almost equal division of the work and responsibility between the workman and the management. All day long the manage-	Standard Practice Instructions.

ment work almost side by side with the men, helping, encouraging, and smoothing the way for them, while in the past they stood one side, gave the men but little help, and threw onto them almost the entire responsibility as to methods, implements, speed and harmonious coöperation. Planning and Despatching.

To resolve all efficiency into certain definite principles was a service comparable to the analysis of all matter into a limited number of chemical elements. The principles of efficiency are applicable to absolutely all human activity, and, though discovered in industry, by the aid of them, the Emerson Company has done betterment work in an institution as remote from industry as a hospital. Just as, by applying the tests for the different chemical elements, a qualitative analysis can be made of any substance, so by searching for the presence in any work of each of the principles of efficiency, a qualitative analysis of its efficiency can be made, that is, it can be determined in what respects the work is efficient and in what inefficient. In this paper I submit to the Society such a qualitative analysis of American engineering education. A sufficient reason for my using Emerson's principles is that they are to me familiar tools. A college, of course, has its business side, an enquiry into the efficiency of which has been conducted by Morris L. Cooke and reported to the Carnegie Foundation under the title of "Industrial and Academic Efficiency." This paper is confined to the educational work of the technical college. Probably many of the suggestions that I make will be considered impracticable; but it is only by the successful accomplishment of things that the so-called "practical man" thus condemns off-hand, that the science of efficiency has attained its actual measure of achievement.

I. IDEALS.

The ideals of a college, at least of its faculty, are commonly known as the "college policy." I suppose that every college

faculty talks in faculty meetings about its "policy" and thinks that it has one; but that sacred thing is likely to be composed of a number of rather unrelated dictums, like "We do not accept substitutions except in kind," and "We discourage the admission of special students"; while a college policy in the sense of a clearly defined ideal, toward which, in all its activities, it is constantly, consciously, and consistently striving, is apt to be lacking.

The German technical university has a definite and clear ideal. It is to be the leader and guide of German industry in the application of science to its work. This ideal has the support of the state, the faculty, and the students. The professor is expected to be, and is, a producer of new knowledge, of which German industry receives the benefit; and this is a principal cause of German scientific and industrial eminence. Students are a by-product, of which twenty-five per cent. or more are reclaimed. Now a single correct ideal does not make efficiency, but it is a step in the right direction; and certainly the German technical university has it.

At the head of the American university is usually a board of regents or of trustees, who are not supposed to be educators and whose ideal for the technical college, if they have any, is probably best expressed in the words of the Morrill Land Grant Act—"to teach such branches of learning as are related to agriculture and the mechanic arts." That means, to pass along the rudiments of technical knowledge to successive classes of undergraduates. Far from the professors being supposed to be fountains of new knowledge, they are considered to do well if they can keep their own attainments abreast of the progress of industry. For the achievement of this ideal the regents or trustees are dependent upon a faculty which is usually thoroughly permeated with the German ideal. In the usual American technical college the ultimate authority does not recognize or support the ideal of discovery of new knowledge, therefore research cannot be efficiently carried on; the faculty accepts with reluctance, as something forced upon it from above, the ideal of merely giving instruction and

strives futilely to follow its own ideal. A certain famous American physicist, after stating the researches that he expected to make during the next session of his university, was asked: "What will you do with your students?" "Neglect them," was the reply. Neglect of students does not tend to efficiency of teaching.

It behooves every American college faculty to consider seriously what the ideal of the institution really is, not what the faculty would like it to be; and, unless reform, rather than efficiency, is sought, to bend its energies to the loyal support of that ideal. On the other hand, I have before stated to this society my belief that a college teacher cannot command the respect of his students sufficiently to secure high efficiency unless they recognize him as a first-hand authority and source of knowledge in his subject instead of a mere conduit from original sources to his students. It therefore behooves the ultimate authority of the university to accept the ideal of production of new knowledge and properly to support the pursuit of it. There can be only low efficiency where the two ideals are in conflict. There can be fair efficiency, in the pursuit of either ideal where it alone is held and is consistently followed. There can be high all-round efficiency only where both ideals are recognized and harmonized.

Another ideal that requires clear definition is whether the college is to give a broad general grounding in the fundamentals of engineering, or is to give a highly developed, but narrow, education in some specialty. The former is becoming more and more recognized as the only proper ideal of the undergraduate courses, the second being reserved for graduate specialists. In spite of this, the teachers, having necessarily developed into specialists, tend to try to develop even undergraduate students into specialists in their own lines. Also the curriculum, under the care of these same specialists gradually becomes overgrown with specialties. The professor of electrical engineering, for example, thinks that a three-hour course in wireless telegraphy is something without which no one can properly be called an electrical engineer. The senior

"electricals" are carrying only twenty-two semester hours, so of course they can take on three more. At the next faculty meeting, therefore, the professor recommends a three-hour course in "wireless." Faculty courtesy, of course, requires that the professor should have what he wants in his own department, so behold the hapless senior electricals carrying twenty-five semester hours. Meanwhile the preservation of a curriculum well balanced in the fundamentals of engineering, being everybody's business, is nobody's business.

II. SUPERNAL COMMON SENSE.

The efficiency principle of supernal common sense requires nothing less than the application to the work in hand of all the wisdom and knowledge that can be brought to bear upon it. It is a very grateful task to the technical professor to rub this principle into the industrial manager, who is prone to employ a cheap and uneducated draftsman to work out by empirical thumb rules from a hand-book, problems which the professor knows would be much more cheaply and efficiently done by himself, on a basis of real science, and for a large fee. This is one of the vexations of the professor's career. Let us, however, consider the technician in the act of teaching.

When, as dean of the engineering college of Syracuse University, I tried to apply the principles of efficiency to the work of that college, I found myself at once in the thick of problems of psychology and pedagogy. Considering that all teaching is an application of these two sciences, it has ever since seemed to me strange that from my first day as a young instructor I was not placed under their guidance, for it is self-evident that there can be no efficient teaching except in obedience to their laws. I was struck also by the fact that those students who had athletic ambitions were training to keep their bodies in the best possible condition, but all students, as far as conserving their brain power was concerned, were living haphazard lives. It seems plain that the man who wishes to use his brain at maximum efficiency should live under a proper regimen of diet, exercise, sleep, recreation,

and study; in other words, should train as assiduously as the athlete, and much more continuously.

Now in psychology, pedagogics, and physical training, I had precisely that little knowledge which is a dangerous thing. Moreover I had not time to master these subjects. Any technical teacher is likely to find himself in very much the same situation. Our own subjects are big enough to absorb all of our time and labor without any prospect of our ever attaining exhaustive knowledge of them. In as far as we allow ourselves to be diverted from them, our proper usefulness is diminished. The solution is to be found in the application of the next principle.

III. COMPETENT GUIDANCE.

The facts which I have stated in the last two paragraphs lead me to believe that every technical college should have as staff advisers an expert professional teacher, and a physician who has specialized in physical training, while efficiency itself should be under the charge of an efficiency engineer. Those members of the Society who are not familiar with staff organization are referred to Mr. Harrington Emerson's books, "Efficiency as a Basis of Operation and Wages" and "The Principles of Efficiency." In special cases still other staff officers might be necessary. I am satisfied that in any case, the three above mentioned are essential to the best efficiency. I mention here only the chiefs of staff. Each chief should, of course, have such subordinate assistance as is required by the amount of work on hand. Undoubtedly most boards of university regents or trustees would object on the ground of expense to the employment of pedagogic, medical, efficiency and other staff. It is difficult to convince even university authorities that brains are really needed in the conduct of an institution, and that, though they are costly, in the end they pay better than any other investment. It must be recognized that knowledge is the price of efficiency, and they who will not pay for the former cannot have the latter. Those of us who have the good fortune to belong to colleges which are

parts of universities, can probably appeal to the self-sacrificing spirit common to teachers, to obtain the assistance of experts from the other faculties. At Syracuse I laid my pedagogic and psychological problems before Dean Street of the Teacher's College, and found him more than willing to advise me. If, by similar means, an actual demonstration of improved efficiency can be made, a basis will be secured on which to appeal to higher authorities for financial support.

Another difficulty which will have to be met is unwillingness to accept staff assistance. Some teachers will doubtless feel affronted by the suggestion that their work should be inspected, and that they should be advised by a pedagogic staff. Probably very few students will at first accept the idea that they should go into training for their scholastic work. These difficulties are to be overcome, precisely as the objection of industrial workers to staff guidance is overcome. A selected few are first to be found who appreciate and willingly accept staff guidance. The efforts of the staff are at first to be concentrated on these, and upon them a demonstration is to be made that they profit by those efforts. The benefits received by them will make others more willing to accept the same advantages, and the work can gradually be extended.

Dealing, as we do, with immature youths, the proctor system of the English universities would be a valuable addition to our staff. The function of the proctor is to keep in close touch with a group of students assigned to him and to advise them both as to college and outside affairs. All of us know that our students, notably the freshmen, would benefit greatly by close touch with a wise and friendly adviser. The technical faculties are too heavily burdened for them to assume this function. I wish it to be clearly understood that I do not anywhere in this paper advocate adding to the labors of the present teachers. On the contrary they should be relieved. In supervising students by proctors, it is necessary to remember that too close keeping of an adolescent in leading strings is fatal to his development, a fact which nature has recognized by giving him a strong instinct to rebel against it.

At the same time, he is not yet fit for complete self-guidance. The situation is critical and calls for careful selection of the proctors and for their classification as junior officers of the psychological staff. If, in conjunction with betterment work in the institution itself, courses in efficiency could be given therein for which credit would be given, selected upper class men who were taking the efficiency course could be made proctors over the freshmen as part of its work. I mention this only as a temporary expedient, recognizing that betterment work in a university must prove itself before financial support can be got for it. As soon as possible the proctors, or tutors, should be regular salaried officers of the university administration. They will doubtless pay for themselves. In an institution where the students pay tuition, a proctor would not have to save many from the various pitfalls which drop the unwary from the rolls, in order to earn his salary. In state universities the economy would return to the public indirectly, but really, by saving students from failure, by guiding them into careers for which they were suited, and by enabling them to graduate with sounder bodies and better minds and characters.

IV. DISCIPLINE.

In the matter of discipline, the American institution of learning has a tremendous advantage. Those who are accustomed to think of discipline only in terms of the man-of-war would probably, on a superficial examination, be impressed that there is no discipline in the college; but that is far from the fact. With all their free and easy ways, college students are obedient; and they usually regard their teachers with respect, and often with affection. Moreover, they are filled with an overflowing love for, and loyalty to, their Alma Mater, which, though sometimes mistaken in its expression, is very real and offers an unfailing appeal to them on behalf of all right action. It would be to any industrial organization an asset of untold value to have among its employees an *esprit de corps* at all approaching "college spirit."

With local variations, there is, in the main, only one direction, in which improvement in discipline suggests itself to me. That is in the more careful selection of young men for the engineering profession. I am not speaking here of the educational requirements for admission. To all of us cases are familiar of students, struggling along in the technical colleges, who are totally unfit to be engineers. I remember one young man who turned in a design of a boiler, with the mouth of the furnace blanked off by a solid steel plate, and who afterward found a more congenial career on the stage. Of course the "bust-notice" usually gets rid of most of these, but there are many who have too much brains for that, who drag along to their own unhappiness and the despair of the faculty, and to ultimate failure in life, unless they go into some other work before they are too old. It should be one of the functions of the proctors to find such cases very early in their student careers, and to bring them to the attention of the faculty. The latter should advise, and should have authority, advice failing, to drop from the student rolls those unfit for the engineering profession.

V. THE FAIR DEAL.

Under the head of the fair deal we can gladly mark the technical college 100 per cent. (minus) and let it go at that. While the college has not attained absolute perfection, that industry is indeed a shining light, in which the workers have as much confidence as prevails in a college in the justice of the administration. Such confidence is a great advantage in undertaking betterment work. For example, the dropping of students for unfitness for the engineering profession, advocated above, could not be undertaken by any faculty in whose fair dealing the students did not have confidence.

VI. STANDARDIZATION OF CONDITIONS.

The purpose of standardization of conditions is not only to make conditions constant, or standard, but to make them as

suitable as possible to the work in hand. The idea of adaptation is quite as prominent as that of standardization. Adaptation, of course, works both ways. Adaptation of conditions to the work is most desirable, but is often impossible. Man has been obliged, in the main, to adapt his work to his conditions; that is, to do what his circumstances allowed. Far be it from me to decry a noble effort to do needed work under adverse circumstances. Humanity owes its progress to the fact that heroes, saints, and martyrs have sacrificed even their lives in such attempts, but that is aside from efficiency, which is the subject of the present paper.

Under the head of adaptation, or standardization of conditions, there is more need of a propaganda among the financial authorities of colleges than among the members of this society, who like other college professors, are undoubtedly as insistent on proper equipment for their departments as they can be without becoming completely disliked in the president's office. Among the financial authorities, equipment is often a case of cutting the coat to fit the cloth; but, when a university puts a half million dollars into a gigantic stadium and another quarter million into a gymnasium, while its engineering college is turned off with a niggardly equipment, it is plain that its administration is inappreciative of the application of this principle of efficiency in technical education.

It is also obvious that a college should not undertake work for which, by location or otherwise, it is manifestly unsuited. One cannot think, for example, that a school of marine engineering is likely to be highly efficient in an inland college remote from any more striking example of naval architecture than a canal boat. If we had had pedagogic guidance, we should long ago have recognized the superiority of the practical-theoretical method of teaching, which is followed only by the few institutions that have adopted the coöperative, or part time, plan over the theoretical-practical plan which is still followed by most. If we had designed a man on the drawing board and then built him in the shop, we should probably have made him so that he would have inquired first

Why? and then What? and then How? He would have been a highly intelligent creature whose career would have come to an end the first time he was confronted by an unknown and unanalyzed danger. Imagine him in the path of a speeding automobile. It would be time to telephone for the undertaker, before he had satisfied his philosophic mind that there was sufficient reason for a quick dash to safety. Man, being the product of a long struggle against adverse conditions, has been so firmly impressed by heredity with the necessity for quickly deciding How, and of the inadvisability of bothering with What and Why, unless the thing later seems worth while, that his mind will work that way, even when, on the whole, it would be rather better if he reversed the process. Much as we may deplore his perversity, we shall succeed best by operating him in his natural direction of working.

Hence we shall teach best, if, instead of pouring academic knowledge into our students for four years, and then turning them loose to find, on their own resources, its relation to practical industry, which seems strangely indifferent to their learning, we bring them, before and during their college courses, into actual working contact with industry and coördinate their academic instruction as closely as possible with their practical experience. This is a standardization of conditions which, by coöperation with industry, is within the reach of all.

VII. DETERMINATION OF STANDARDS.

For the sake of brevity, I shall discuss under this head only one standard which the technical college conspicuously lacks. That is one of student capacity. How much work of any given subject can a student reasonably be expected to do in an hour? How many of us are there who can answer such a question, even with reference to our own subjects only, on any basis of real knowledge? The most of us probably know only that as students, we ourselves succeeded in learning about so much per lesson. How much time had we per lesson? How much time has the student now? How many of us know, not guess, the answers to these questions? In the face of these

uncertainties, the inevitable tendency of the specialist, who realizes much better the infinite ramifications of his own subject than he does its relative unimportance in the general scheme of things, is to pile onto his students always a little more and a little more, until the task becomes an impossibility. The result is inevitable. On the one hand the student must resort to cramming, to memorizing, to bluffing, in order to get through. On the other hand the teacher, for the sake of his own reputation, must not appear to be unable to communicate his knowledge to a reasonable proportion of his students, the only tangible evidence of which knowledge is a passing mark reported to the registrar. Hence a continual loading of the subject is bound to result in a continual decrease of thoroughness on the part of the student, and a continual lowering of scholastic standards on the part of the teacher. I was once one of the assistants of a very eminent engineer, who had the habit of handing out to us more work for a day than we could do in a week. Fortunately one of us soon discovered that he forgot the tasks, as soon as he had assigned them, and kindly gave the rest of us the tip. Thereafter, I received orders for the most preposterous tasks without either a protest or a smile, did what I could and forgot the rest, which my chief also very kindly did. The results, between the overloaded student and the specialist professor, are bound to be similar.

There is need here for some time study work of the very highest grade. The idea of time study of mental work may strike some as impracticable; but Dr. F. W. Taylor wrote me that the first time studies of which he ever knew, and which first suggested the idea to him, were made by Professor Wentworth on work in algebra, when Taylor was one of his students, and that Wentworth based his assignments of lessons on these studies. As soon as it has been determined what the students can reasonably be expected to do, that much should be assigned to them and no more, and they should then be absolutely required to do it. The result can not fail to be a great improvement in thoroughness; and, while the diploma

may not certify that graduates know so much, it will mean that they really know a great deal more, beside which the moral training of always fairly and squarely meeting a reasonable requirement, will be of inestimable value.

VIII. STANDARDIZATION OF OPERATIONS.

I have been told that Gantt classifies the human race into routine workers and experts. There is something like that in his book, "Work, Wages, and Profits," but I cannot say where I got it in precisely that form. This is by way of apology to Mr. Gantt, if I have misquoted him. Anyhow, the routine worker can do only what he is told, as he is told to do it, following over and over a beaten path, until he attains speed and skill as habits. The expert is constantly confronting new conditions, under which, by the application of invariable principles, he works out methods in infinite detail to meet each particular case.

The betterment man is accustomed, in industry, to blaze the trail for routine workers. In the technical college he is to improve the education of embryo experts, who are themselves to become pioneers. It would be fatal to their development to make them work according to hard and fast rules such as are set before the routine workman. On the contrary, problems must be set before them which they must be left to solve as nearly on their own resources as possible. Only by so doing can they attain the necessary independence and self-reliance. The industrial operation is standardized in order that the routine worker may do it in the most efficient way. It is vastly less important that the student should do his work in the best way than that he should do it himself. An excellent paper along this line was contributed to the American Society of Mechanical Engineers some five years ago by Dr. Lucke, under the title of "The Function of Laboratory Courses." After myself experiencing conviction of sin as a result of that paper, I entirely withdrew from my senior laboratory students all written instructions for their work

and required them to work out their own solutions of laboratory problems. Nevertheless this led to a standardization of the operation of such solution along the following lines:

1. The assignment of a problem; for example, to determine the thermal efficiency of some engine over its complete range of load;

2. A preliminary lecture, giving only so much explanation as was absolutely necessary;

3. The division of the students assigned to a problem into certain standard committees,

The Foreman, and Committee on Stations and Duties for Experimental Work,
Committee on Apparatus,
Committee on Runs and Logs,
Committee on Final Report, and
Committee on Prediction of Result;

4. The rotation during the year, of each student through all the committees, so that he gained an experience of all phases of laboratory work;

5. The preparation by each committee of a report on its part of the problem, comprising definite instructions for the conduct of the further work;

6. A seminar in which each committee presented its report, which formed the basis of action by the whole squad;

7. A preliminary report on the problem from the whole squad;

8. The performance of the experimental work under direction of the foreman, in accord with the preliminary report;

9. The calculation of results by the whole squad under direction of the foreman; and

10. The submission of a final report by the whole squad.

The above is submitted as a concrete example of the fact that it is possible to standardize operations and at the same time to put upon the student the responsibility of solving his problems for himself. It would be an impertinence for me to offer to my fellow members any further suggestions as to

the standardization of their own operations. As to the student, many of his operations might be standardized with improvement in his efficiency, and without decrease of his independence. For example, it was not until my own fourth year in college that I learned how to study a technical text. Until that time, when the author said, "It is obvious that," I immediately set to work to dig out for myself the conclusion, which in most cases was very far from obvious to me. I finally found that the author usually gave his reasoning on the next page, a discovery that has saved me many a weary hour since. Doubtless it developed my cerebral tissue to think for myself the thoughts of Cotterill, Remsen, Thurston, and their peers; but, for a college boy, the task was almost too much, as some narrow escapes from being sent home painfully impressed upon me. Probably others have failed from similar causes, who might have been saved to professional careers merely by standardization of the operation of preparing a lesson.

IX. STANDARD PRACTICE INSTRUCTIONS.

I have often had occasion to advise a student to take a tutor, not to teach him the subject, but to show him how to study it. At present such occasions come to a college teacher in a haphazard way. If he is interested in his students and enquires into the troubles of any of them who are not getting along, or if he is the man to attract their voluntary confidence, he is likely to have such opportunities. If he is absorbed in his subject to the exclusion of human interests, he may not care or even know how his students are getting on. In this country we are apt to condemn a man of the latter type, but he is more apt than the other to know his subject, and no man can teach what he does not know himself. To know exhaustively a subject in up-to-date engineering is one man's job, and the only way to enable him to do it at high efficiency is to relieve him of distractions in other directions. The college teacher's business should be his subject, and the responsi-

bility for student welfare should be in the hands of a separate corps of workers; while the head of the college should be relieved of the details of both kinds of work, but should be a man broad enough and big enough to dominate both classes of workers and to control and coördinate their work.

The proctors should find out, as a matter of regular duty, instead of leaving it to the teachers to find out by chance, whether any young man is working inefficiently; and, if he needs standard practice instructions, they should have the means, by conferences with the pedagogic, psychological, and medical staff, and by reports to the head of the college of needed action, to make sure of his getting them.

Standard practice instructions along other lines, for example the notation of drawings, may with advantage be provided, and commonly are; but these are matters of detail, which vary with local conditions, and do not admit of general discussion.

X. PLANNING AND DESPATCHING.

In the application of the efficiency principle of planning and despatching, the technical college is far ahead of most

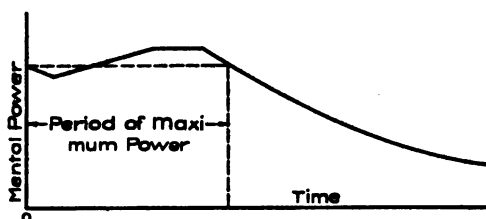


FIG. 1.

industries. The curriculum as a whole is planned from the outset, subjects are arranged in logical sequence, and the time allotted to each is predetermined. Classes are despatched as to hours and rooms, a year in advance. If, however, we examine the basis of scientific knowledge for our elaborate planning and despatching, the bubble of our satisfaction is imme-

diately pricked. For example, why is the standard period for a recitation or lecture one hour? I have been unable to find any better reason for it than that the hour is a clock unit.

Now it is known that in mental work, the relation between time and power is somewhat as shown in Fig. 1. First there is a period of decreasing power, similar to the "warming up" in athletics; then a period of increasing power; then one of nearly constant power, a maximum plateau; and then fatigue sets in with continually decreasing power until complete exhaustion is reached. Also it is known that, in the early stages of fatigue, rest brings quick recuperation; while, after exhaustion is approximated, recovery is slow and rest must be long. If every one had the same curve of time-power, it would be easy enough to find the time of maximum power ordinate; but there are great individual differences. In some cases the time of warming up is inappreciable; in others it is very long. Some individual curves show an absence of the maximum plateau. With these individual differences, is it feasible to find a composite curve of which the period of maximum power will approximate the general average? Or, if not, is it feasible, in drafting room and similar work, for individuals to recognize their own periods of maximum power, and to work accordingly? The composite period of maximum power being determined, how many such periods per day will produce the maximum efficiency? What should be the interval between such periods? Perhaps the psychologists know the answers to these questions. My own transfer to betterment work in industry has made other matters so much more pressing that, for myself, I have been obliged to retire them from present consideration. As far as I know, the psychological, pedagogic, and medical staff have a good piece of work cut out for them to find the answers. Probably original research will be needed; but efficiency engineers would not get far, if they were daunted by such a necessity.

When we know how long a student ought to work at one time, when we know how many hours he ought to work in a day, and how many days in a year, we shall be able intelli-

gently to determine the number of semester-hours he ought to carry. When we have time standards for the students' work, we shall know how many semester-hours should be assigned to each subject. Let us not be scared by the number of such standards required. A certain large industrial company has sixty thousand such. When we know student capacity and have time standards for each subject, we shall be able to build up a curriculum with scientific accuracy instead of by rule of thumb. If the result should be an increase of the number of years of the course, I should regret it; but, if it is necessary to pay that price to secure efficiency during the engineer's working years, it must be paid. I expect that general betterment, in education as in industry, will so greatly increase working capacity that there will be no such necessity. Connected with any effort to establish time standards for subjects, there is bound to be a vigorous pruning, an analysis of subjects into their fundamental principles, and a concentration of effort on instruction in these, and in practice work in their application, together with the cutting out of all dead wood, and, in undergraduate courses at least, of refinements which are of interest only to the specialist. Such an elimination of waste labor will in itself very highly conduce to academic efficiency.

Coming to detail despatching, many students are in great need of its application to them individually. Some years ago a senior came to me and complained that he did not have time to do his work. I said to him "Getting your work into your time is a good deal like getting your clothes into your trunk. If you stand across the room and throw things at the trunk, just as you happen to find them, you have to get several fellows to sit on the lid; but, if you fold things neatly and stow them in orderly fashion, you probably have the top tray empty. Sit down and let us make out your weekly schedule." The schedule being made out accordingly, showed no work from one o'clock Saturday afternoon until eight o'clock Monday morning, whereupon I filled in for Saturday afternoon "Physical exercise in the open air." This young man had a

very particular chum in the coeducational department; and nearly every Saturday afternoon for the rest of his course, I met him walking with her, whereupon he used to hail me with, "You see, professor, I am sticking faithfully to my schedule." An efficient staff of proctors would have got hold of this young man in his first week in college, and the course of true love might have run smoothly, not only through the senior, but the junior and sophomore, and perhaps even through the freshman year, and that without neglect of lessons, by virtue of running on schedule time.

XI. IMMEDIATE, ADEQUATE AND RELIABLE RECORDS.

The technical college has an abundance of educational records which in the main are immediate, adequate, and reliable from the point of view of the faculty, and adequate and reliable, but not immediate enough, from the point of view of the student. Their reliability may seem questionable, seeing that the marks which a student receives, represent merely a teacher's general estimate of the value of his work; but experienced markers, working independently, will grade the same within a few per cent., if they have time enough to work with reasonable care, so that, unless the faculty is obliged by overwork to mark hastily, the records ought to be substantially reliable. It is my own belief that a student ought to know all of his marks very promptly. Yet I have known a worthy professor to move, and his faculty to pass a resolution, forbidding teachers to acquaint the students with any marks; and, unquestionably many teachers prefer not to tell what marks they give. I could never bring myself to much patience with this attitude. It always seemed to me like mere shirking. If a teacher gives a mark, he ought to be able to justify it by good reasons; and those teachers who willingly tell their marks are not bothered by unreasonable complaints from students, nor do they give cause for reasonable complaints.

At my own Alma Mater it was the custom to post on each class bulletin board at the end of each week the names and

marks of all students whose average for the week was unsatisfactory in any subject; and, one month before the end of each semester, the names of all students who were in danger of failure at the end of the semester. Such timely warnings doubtless prevented many failures; and, except that notice of deficiency might better be privately given, the customs are certainly worthy of imitation. Not only the student concerned but his proctor should be informed at once when he begins to receive failing grades and the proctor should at once investigate and start remedial measures.

XII. EFFICIENCY REWARD.

The principle of efficiency reward must be considered with reference to students and faculty. The student has a form of nominal efficiency reward in the marks which he receives; but, unfortunately, there are not many students to whom one passing mark is any better than another. In fact some students regard any surplus of mark above barely passing as a waste of effort and an indication of personal inefficiency. On the other hand, athletics offer, in bodily vigor, excitement, applause, admiration, and the coveted block letter, an immediate and highly prized efficiency reward. Social affairs and student politics offer also excitement, applause, admiration, some power, and very enticing pleasure. In contrast the rewards of scholarship seem few and empty. It is no wonder that so many students are diverted from the supposed main purpose of the college.

By way of increasing the rewards of scholarship in ways that make an immediate appeal to the student, such societies as Tau Beta Pi and Sigma Xi, are of undoubted value. Their usefulness will be increased by such marks of distinction as the institution can bestow on the local chapters. The main solution of the difficulty is to impress upon the student that knowledge is the thing of value, and that, if he gets it, marks and even diplomas and degrees are negligible quantities.

While various means to this end at once suggest themselves, it seems to me that the most powerful is to give the student

an object lesson in the need of scientific technical knowledge, to make him feel his lack of it, by bringing him from the outset of, and throughout his college course into close practical contact with industry by means of the coöperative, or part time, method of instruction. Any one who doubts this, has only to compare those of his own students who have had practical experience with those who have not. While the former, from necessity of spending much of their time and energies in self-support, may be only fair, or even inferior scholars, they do not fail from lack of interest in their work. Once the student realizes that knowledge is what he is after, and not marks and degrees, his efficiency reward becomes immediate, automatic, and unfailingly just.

Turning to the faculty, there are four ways in which efficiency should be rewarded: (1) by salary, (2) by social standing, (3) by promotion, and (4) by opportunity.

As to salary, including under this head old age and service pensions, the subject has been worn threadbare, and there is no profit in discussing it in any length in this paper. The mere fact that the best men are being continually drawn away from teaching into industry and that our ablest engineers are to be found in practice and not in professorships, as in Germany, is proof enough that the reward of our teachers is inadequate. When any institution undertakes betterments, one of the first uses that must be made of financial economies resulting from greater efficiency of the material side of the institution, from immediate, adequate and reliable cost-keeping, from using costly steam heat to warm buildings in use, instead of to kill the campus grass, and from efficient use of buildings and equipment now idle a large part of the time, is to increase the compensation of its teachers.

As to social standing, the situation is not bad; but such distinguished consideration as attaches to a university professorship in Germany, would, of course, hold many men to the teaching career in this country in spite of more lucrative opportunities in practice.

As to promotion, efficiency reward is here directly opposed

to the commonly accepted ideal. The very university president who fails utterly to support research by his faculty, who looks upon it in fact rather as a diversion from their proper work of teaching, will, if he has an important position to fill, seek a man "whose name will strengthen the institution." That means inevitably a man who has been in some way a discoverer of knowledge, because mere teaching and administration, no matter how faithfully and well done, make one known only to his own students. If the ideal is to continue to be merely "to teach such branches of learning as are related to Agriculture and the Mechanic Arts," in order to attain efficiency in its pursuit, efficiency reward must be based upon it; and, when promotion is possible, it must be bestowed upon the efficient teacher. If, without sacrificing our own ideal, we are to adopt in addition, as we should, the German ideal of leading and guiding industry in the application of science to its work, the ultimate financial authorities of our institutions, and finally society itself, which in the end must bear the burden of all education, must learn to support both teaching and research, and appropriately to reward efficiency in both.

As to opportunity, a motive which, to a man of the right type for a college teacher, is quite as compelling as the desire for financial reward or for academic or social position, is the ambition for honorable fame as one who has rendered distinguished service. To the college teacher the means which at once suggests itself to that end is research. The substantial denial of such an opportunity in our technical colleges, removes from them one great and highly prized efficiency reward. I count among my most valued friends one of our most distinguished practicing engineers, a man of surpassing character and of wonderful devotion to altruistic service. Some years ago he was one of our most distinguished technical teachers, in an institution ranked by all as among the best, and by many as the best in this country. Shortly after his leaving teaching for practice, I said to him that I should have thought that he would have stayed in teaching in order to

develop his ideas by research and invention. He replied: "I saw that there was no chance for me to do anything of that kind there."

XIII. FINANCIAL RESULTS.

It may be objected that the proposals above, all tend to greater, not less expense. This is the stock objection of the unconverted captain of industry to all suggestions of greater efficiency. Inevitably betterment work increases the ratio of indirect to direct expense; but experience in industry has fully shown that it increases even more the ratio of production to total cost, so that the final result is a decrease of unit cost. Similarly in education; by causing institution, teachers and students to coöperate in the pursuit of the same adequate and correct ideals; by applying to teaching its own sciences; by placing the workers under competent guidance; by the more thorough elimination of the unfit through discipline; by fair dealing with all concerned; by standard practice instructions for the performance of standardized operations; by the extension of the present system of schedules of classes into one of schedules for individuals as well; by the basing of all planning upon scientifically determined standards of capacity under standardized conditions; by making records immediate as well as adequate and reliable; by rewarding the efficiency of teachers, and by causing students to appreciate the efficiency reward which they have; the result is bound to be an increase of working capacity of both teachers and pupils: and this, in the end, is bound to reduce cost per unit of product.

THE APPLICATION OF SCIENTIFIC MANAGEMENT TO THE OPERATION OF COLLEGES.

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Manufacturers and business men often look upon their own undertakings as peculiarly different from every other apparently similar business. It will not be surprising that every college may feel that it has problems unlike any other, and of greater difficulty. Naturally, the men connected with the colleges and universities look upon their duties as something entirely distinct and apart from those which occupy the attention of people in other walks of life. Yet, as a matter of fact, these problems are very much alike.

A college is a big business enterprise. Its product is the attainment of high ideals in scholarship, in character development and culture, and the preparation of youth for the activities of life and for intellectual and spiritual leadership. In place of mechanical output, its product is men. But the element of cost enters in just as much as in any other business enterprise, that is, we want to get as much as possible for the money. We cannot always measure the value of the output in dollars and cents, yet every one likes to feel that the money which he contributes to educational and philanthropic purposes is well expended, and future benefactions often depend on showing a high efficiency.

One of the points that show the need of Scientific Management is that many institutions have difficulty in running on their endowment income and tuition fees, and find themselves constantly face to face with a deficit or at least hampered in the extensions and expansions they would like to make. It may well be that a critical examination of the expenditures and methods of some of our colleges may be more helpful to

them than more money. Again, the professors complain that so much of their time is taken up by correcting examinations and assigning marks, and maintaining records, petty details, deadening routine, that they have not the freshness and the buoyancy of intellect that leads to creative thought, to advancement along the lines of research.

In his report to the Carnegie Foundation, Mr. Morris Llewellyn Cooke has stated "A further increase in the efficiency of the teaching staff will be obtained through such specializing as will come as the result of functional management. There are some things that are clear. During the interviews which the writer had with college professors, he found them spending time in taking inventories, keeping track of appropriations, mimeographing examination papers, and handling routine correspondence. These things are clerical work, and should be handled outside the teaching field, and not as a part of the teacher's duties. In addition, there are many other things, including management of the buildings, which might easily be centralized and done better by officials who can devote their time exclusively to them. Such changes would leave the professor more time for the work for which he is especially fitted.

"The manifold duties carried on by the college professor seem overwhelming. I saw a single individual personally assume the direction of a large building including laboratories, machine shops, power plants; maintain order and discipline among seven hundred at times boisterous spirits; direct and inspire a teaching force of a score of rather unusually able men; and keep in touch with a large body of graduates. The college professor does not realize how many distinct functions he performs. The high-priced presidents of our railways, banks and steel companies would not dream of performing this variety of functions. They would refuse to do so because they know they could not do them well."

"This part of raising the efficiency of the college professor will have to be done by building up central agencies for doing much of the work he does now, and for doing it so much better

than he possibly can, that he will be glad to relinquish his responsibilities in these respects."

In contrast with the commercial and industrial world, there will be found a general lack of intensiveness and snap everywhere pervading the universities and colleges. There is no haste in attending recitations and plenty of time and leisure to discuss matters with those met on the way. The professor is occasionally five or ten minutes tardy in meeting his class. If the young man is to succeed later in life, he must realize the necessity of intensive application to his work during that time when he is assigned tasks; he must realize that an hour of his time is a valuable thing and cannot be carelessly wasted.

In an address before the University of Pennsylvania, Dr. Taylor, referring to graduates of technical schools, said "Why is it that these young men are discontented and of practically little use during the first year or two after graduating? To a certain extent, this is unquestionably due to the sudden and radical change from years spent as boys, almost solely in absorbing and assimilating knowledge for their own benefit, to their new occupation of giving out and using what they have for the benefit of others. To a degree, it is the sponge objecting to the pressure of the hand which uses it. To a greater degree, however, I believe this trouble to be due to the lack of discipline and to the lack of direct, earnest and logical purpose, which accompanies to a large extent modern university life.

"As to college discipline, it cannot be good training for after life for a young man deliberately to be told by the university authorities that he can flagrantly neglect his duties sixty times in one term before any attention will be paid to it, while, if in business, the same young man would be discharged for being absent two or three times without permission. The boy who joins the football squad is given no sixty cuts a season, nor is he allowed to choose what he will do. He does just what some one else tells him to do, and does it at the time and in the manner he is told and one or

two lapses from training rules are sufficient cause for expulsion from the team.

"I believe it is possible to so train young men that they will be useful to their employers almost from the day that they leave college, so that they will be reasonably satisfied with their new work, instead of discontented, and to place them upon graduating one or two years nearer success than they now are; and this can best be accomplished by giving them an earnest purpose through six months' contact early in their college life with men working for a living; by rigidly prescribing a course of studies carefully and logically selected, and with some definite object in view, and by subjecting them to a discipline comparable with that adopted by the rest of the world.

"Of all the habits and principles which make for success in a young man, the most useful is the determination to do and to do right all of those things which come his way each day, whether they are agreeable or disagreeable.

"Is not the true object of all education that of training boys to be successful men? I mean men successful in the broadest sense, not merely successful money-getters, successful first in developing their own characters, and second, in doing their full share of the world's work."

The need of scientific management is further shown by the limited use of the rooms in college buildings. As an instance, it is reported that the president of the University of Wisconsin conducted an investigation of one of the main buildings of his institution, and found that the rooms in it devoted to teaching were used, on an average, only three hours a day. This is about the average amount of use in many instances in several other universities and colleges. The proper assignment and utilization of the rooms during the year would double the capacity of the college buildings.

In illustration of the point of using, or not using, the same room for different purposes, Mr. Cooke has described two large lecture rooms. "One of them at the Massachusetts Institute of Technology was reserved for a lecture which took place

six mornings in the week at eleven o'clock. Owing to the fact that the room was made more or less a storehouse for physics apparatus, it was rarely allowed to be used for any other purpose. On the other hand, at the University of Toronto, the far-sighted professor in charge of the department had seen to it that in the construction of his lecture table every wire and pipe had a connection both above and below the floor, so that on an hour's notice it could be removed and a piece of flooring already provided be put in place and the room turned over to the Cercle Francaise. Instead of having a fixed blackboard back of the lecture table, he had both the board and the partition back of it so suspended that when the room was to be used for theatrical purposes, they could be raised entirely out of view, thus providing both stage and flies for a neat little theatre. The professor also insisted that all apparatus be removed from this and the other lecture halls at the conclusion of the exercises at which the apparatus was used."

Further, so large an investment as is represented by the grounds and many valuable buildings, and the expensive equipment of the modern college plant ought not to permit the buildings to remain vacant and idle during four months of the year. In a few instances, as at Columbia and at Harvard, this is to some extent overcome by summer schools, which have the advantage of unusual facilities and equipment, and should be made to yield an income.

There are four general principles in scientific management and they are all applicable to a college or to a university; but the economies to be attained through them come about only through the hearty coöperation of everybody who is concerned.

"FIRST, A LARGE DAILY TASK.

"Each man in the establishment, high or low, should daily have a clearly defined task laid out before him. This task should not in the least degree be vague nor indefinite, but should be circumscribed carefully and completely, and should not be easy to accomplish.

"SECOND, STANDARD CONDITIONS.

"Each man's task should call for a full day's work, and at the same time the workman should be given such conditions and appliances as will enable him to accomplish his task with certainty.

"THIRD, HIGH PAY FOR SUCCESS.

"He should be sure of large pay when he accomplishes his task.

"FOURTH, LOSS IN CASE OF FAILURE.

"When he fails he should be sure that sooner or later he will be the loser by it."

But, it is argued, a college has to do with spiritual and intellectual development and the higher mental and moral attainments and interests of life. Undoubtedly this is so, and it is just what we are aiming to accomplish through scientific management, by so readjusting present working conditions as to enable the professors and their staffs to grow and have the opportunity to consider the higher ideals and properly guide the college boys thereto. A high-salaried man should not be doing those things which a lower-salaried man can do very nearly as well. Some one else should do these things for him.

The term "functional management" is given to that phase of scientific management which provides that each man from the highest salaried to the lowest shall have as few functions as possible to perform.

Historically, there has been a good deal done in the line of functional management since early days. In the old district school, one teacher taught everything in the grade. Now, even in the elementary schools, the best of them, one teacher, who is particularly good at reading, or geography, or music, teaches the reading or the geography or the music for several grades and often has no other subject to teach. This is, of course, the case in colleges, for the teaching is departmental. Now this is unconsciously the beginning of functional management, although not technically so called. Scientific study and the conscious application of the principles of management will bring about still further improvement.

Most of the teachers in colleges are men of rare ability who have devoted years to training themselves in a special branch of knowledge. It is a matter of supreme importance to them that they should be able to devote every possible minute of their valuable time to the use of this training and knowledge. Each individual in an organization should count for his maximum.

Under functional management, a man is protected in the performance of the highest kind of work he is competent to do and relieved of the things which can be accomplished by other agencies. Applied to the college, this functional method will mean that the work of any institution will be divided into a large number of functions, and that in each of these functions some one person must be supreme. There is a wide difference between dividing all the work into a certain number of positions, the occupant of each position having many functions to perform, and dividing the work into a certain number of functions, with some one person supreme or expert in each function.

Functional management is based on the belief that there is one best way to do a given thing. This best way can be determined by scientific methods and expressed in complete detail in writing as a standard.

Now how will this help the teacher? Everything must be done to conserve his time. The higher his position, the greater will be the incentive to do this. One of the principal ways of doing this will be in having much of his routine work done for him. Undoubtedly the work would not be done quite as well as the teacher could perform it, and yet it would pay if the time of the professor thus saved could be utilized in more important duties, and the direct return to him would be his ability to command a larger salary as a result. For instance, examination papers are often mimeographed or typewritten. The professor ought not to be obliged to do this himself. There should be a recognized department from which he is entitled and expected to receive a definite mechanical service of that sort.

One thing could be done as an entering wedge. Four professors, not necessarily teaching the same subjects, could arrange together to occupy the full time of a low-salaried instructor, who would perhaps do no teaching or lecturing, but would lighten their labors in the line of correcting examination papers, tabulating results and marks and keeping records, and furnishing them with carefully written reports of the results. He could even conduct examinations, and edit and typewrite the professor's notes and lectures, with the result that each of the professors would be able to take one class more, and would much prefer so doing to carrying on the routine work previously burdening them. Such service would enable them to possess a broader outlook and consider the big things in their respective fields.

It may be argued that the professor cannot keep in close touch with the individual members of his classes and know how his classes are assimilating what he furnishes them, without his actually correcting the examination papers. The answer is that it is possible for the papers to be returned to the professor for his perusal without his being required to put himself in the critical mental attitude necessary to detect each error and determine and affix the exact percentage of excellence. On the other hand, his mental attitude would be one of constructive study and to attain this, a perusal of every paper would not be necessary.

Again, there are many courses that remain practically the same from year to year, and which in the presentation require special apparatus or much mechanical preparation. At present, most of this is done by the man who delivers the lecture or by an assistant who has been trained to do this through years of practice. In industrial establishments, more complicated work than this is frequently done by ordinary workmen under written instructions. There is no reason why, for each lecture there should not be written instructions in complete detail, specifying exact locations, etc., with lists of apparatus, to be given to a low-salaried man. The man might even actually go through the performance of the experiments

in order that the time of the professor might not be wasted when he went over them preparatory to the lecture. This would relieve the professor of much subordinate work that consumes his time.

In organizing these functional activities, the best progress will be made by doing things as gradually as they can be well done. It will not be best to require everybody to use a given functional agency when it is first started. Duties will be willingly relinquished to those who will discharge them more efficiently, if thereby relief to do larger things is attained. A purchasing agent will find his time profitably occupied in doing the buying for those who are anxious to use his services, particularly if they are impressed with his efficiency and genuine helpfulness. It will be better for him to make a few purchases and make them right, than to force his services on those who do not feel that they require them. For the result will be that practically every one will turn over the purchasing to him within a year or two, without the necessity of his forcing his services upon them. People are always glad to be relieved of trouble.

Many of the activities of the college are similar to those of ordinary business, such as the buying of supplies for the maintenance and care of buildings, for individual laboratory work, the various forms of printing, reports and catalogues, stationery and office supplies.

The receiving and paying out of money demands an accounting system as comprehensive as that of many a large manufactory or public service corporation. Oftentimes, the care of the college funds is merely a side issue of a man whose mind and inclinations are trained along entirely different lines, along lines of purely intellectual and spiritual pursuits. This, however, is a business matter and should be in the hands of a shrewd, level-headed and far-sighted business man or at least should be handled in a modern business way.

The trustees want to know what things cost and the average institution can give only summaries, and is unable to give a correct analysis or a satisfactory comparison with previous

years. There should be a competent officer, who should devote his entire time to the work, whose business is to study costs, to analyze expenditures according to the teaching departments. For the teaching departments in a college or university are the equivalent of the manufacturing departments of an industrial enterprise. To each should be charged its own direct expense and its proportionate share of all the indirect expenses. The entire expenses, direct and indirect, including the administration, should be divided among the various teaching departments. Such an officer should advise department heads monthly as to the amount of expenditures under their appropriations, and should have authority to prevent expenditure in excess of an appropriation.

The general features of college life, as the library, the chapel and the gymnasium, are operated only because they concern teaching. Following the industrial custom of charging overhead expenses to the various manufacturing departments in proportion to the wages paid in those departments, the net expense of such general features of college life might be charged to the various teaching departments in the proportion of their teaching salaries.

The dormitories, however, as usually operated are producers of income. If, however, a fiscal year shows a deficit instead of an income from the operation of the dormitories, the excess of expense over income may be charged against the teaching departments in a manner similar to the case of the library. The expenses of a building may be charged against the building and at the end of the year divided among the departments using the building in proportion to the number of hours in use.

The fact should be established among all departments that there must be some relation between expense and the amount of work done. At most colleges this can be done by the present accounting staff at no increase in cost.

The typical college building usually has its own janitor. There should be a superintendent of grounds and buildings, in charge also of the power plant and of all shops, with the re-

sult of better service under centralized management. This superintendent may have the direction of a corps of janitors, resulting in improved service and standard and uniform conditions of cleanliness. Methods of housekeeping may be carefully and critically studied and scientifically analyzed, and the best method for each kind of work may be accurately described in writing and adopted as the standard.

Many colleges have dormitories. The average college president has very little idea of the number of helpers really needed in the kitchen, the most convenient arrangement of the dining rooms, and the most efficient method of caring for a large dormitory. The result is that if he happens to hire a good steward or chef, the dining room may be cared for economically and efficiently; if he has a good superintendent, the sleeping requisites and supplies may be bought with wisdom. There is more likelihood that he will get a poor and indifferent employee and the college will suffer in discomfort. If from scientific study of conditions, certain standards along these lines were adopted, it would be comparatively easy to require a new steward or manager to accomplish definite results at given times with a definite number of helpers. Instead of depending on chance, the college would have the accumulated wisdom of its past, in a definite form, recorded in writing, upon which to go ahead and make progress. There would then be no necessity for, nor immediate likelihood of aimless drifting. Many a man, when given a standard plan, is able to work satisfactorily in accord with it, and may even improve it. If he depends on his own initiative altogether, he may fail entirely or at the best attain only indifferent success or the commonplace.

An industrial establishment has found the services of the inspector very helpful and profitable in maintaining the quality of its product. It may be possible that the college should have a similar inspecting agency, to attain uniformity in class-room methods, as to quality of teaching and as to class-room discipline, with the motive of quietly averting those conditions that might result in serious harm. Such an in-

spector might develop methods of training men for the teaching staff, for in many institutions most of the assistants are recent graduates without either the teaching, training or experience with the world that would be helpful to them in their relations with the students. As standards are adopted in a college, it will be necessary to have an agency whose special function will be to see that such standards are properly formulated and maintained in force. This duty might be assigned to the inspector.

The development of the function of purchasing agent will naturally lead to the concentration of supplies of all kinds in one central storeroom, from which everything used in all departments may be obtained, at a great saving of time, money and convenience.

The economical use of the buildings, the planning whereby the various rooms may be utilized each for many more hours per day might be one of the duties of the registration department. And in consequence, the registrar should be responsible for the planning of the hours of the day when courses are to be given, for he has the records indicating the desires of the students as to the courses which they wish to take. If rightfully and tactfully handled, many students would be led to plan out their courses more intelligently and more consistently, and the assignment of classes to rooms could be more easily handled.

Among the results of the application of scientific management, there will be a more genuine and hearty coöperation among the colleges and universities, in the interchange of helpful information and data, and even of members of the teaching staff, who will find themselves as much at home in the atmosphere of one institution as in another. Owing to the adoption of standard methods and standard records based on scientific study, comparisons of costs and efficiencies will lead to more intelligent administration and the more effective training of men for coping with the practical problems of to-day.

SCIENTIFIC MANAGEMENT IN THE COLLEGES.*

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The article in *Applied Science* entitled "The Place of Motion Study in Scientific Management," by Frank B. Gilbreth, despite several defects in style, is not only an authoritative statement of what motion study is, what it has done and what it proposes to do for business; but is also a clear and concise review of what scientific management itself is. It would seem impossible to give a more comprehensive review of the benefits attendant upon the introduction of what he calls "functional" management. The diagrams make this already clear exposition lucidity itself. On reading the article one wonders why the scheme is not immediately installed, not only in every manufacturing plant, but in every corporation and business of whatever kind. It would seem that as soon as the plan is understood, adoption must follow spontaneously. Of course the thought comes into every mind to which the idea of scientific management is new: "*This would require ideal men.*" But even with men as we find them to-day, under the most adverse conditions, the scheme has so many advantages that one would think it should at least be given a trial.

Perhaps it is difficult for the average business man to get the idea termed "functional." Those interested in any enterprise too may say: "How can four foremen run my establishment?" Or the proprietor of a smaller concern may declare "I can run my whole business myself; why do I want four,—let alone eight men around me?" Such a man must fail to realize that the numbers stand for functions not persons and that "9" may stand for 98 or 1998 as well as for one. As

* An abstract of the paper by Frank B. Gilbreth, which is referred to by Dr. Palmer, will be found as an appendix to this article. The editor would suggest to those who are not familiar with Mr. Gilbreth's paper, that the abstract be read first.

soon as the idea of scientific management gets into the mind of any fair, earnest worker for the benefit of humanity, it must be recognized as the only, because the ideal, way to carry on work. Modified of course as it must be to suit every individual concern, the plan will be found triumphantly spreading industrial peace and prosperity in the years to come.

The place of motion study will be of more or less importance depending upon the kind of output contemplated; but in every department it is of far more moment than at first appears. I am thinking of it in connection with the work of education, not humorously as did the author of "Motion Study at Saint Catherine's," but seriously with an appreciation of what hardship might be saved the little boys and girls, the growing youths of our country by a carefully considered plan to ease the unnecessary wear and tear of school and college life.

Because it is far easier to say to a sick man, "Thy sins be forgiven thee," than it is to say, "Arise and walk," the application of scientific management to school and college will be difficult. People are not agreed as to what the product to be expected is; they have not agreed on a definition of education. Any one can see whether he has a piano in the house or not, but no one can see whether or not a young man's mind is properly trained. Just this is the difficulty; what do you want college to do for a young man? Ought it to fit him to harmonize with his environment, to prepare him to study one of the so-called learned professions? Or is your theory any one of the thousand other ideas that are floating about as to just what education is? If one knows what the product desired is, one might even get it from the colleges as they are managed to-day; but if one has no idea of what he expects from an education, how can he hope to be satisfied even under the most ideal management? If a boy is sent to school to learn to read Latin; and if at the end of a certain time he can read Latin, but cannot build a steam engine, there ought not therefore be a complaint of the failure of this college-bred man.

Though I have said there would be difficulties in applying

Scientific Management to education, it would be interesting to apply Mr. Gilbreth's diagram and vocabulary, not to the phase of "education" which has to do with the business side of college life, but with the work of real education itself.

No. 9 would be the teacher at work in the class of from twenty to forty students, whose brains would be the product. The teacher must impart instruction, give and record marks, etc., etc. In any college to-day No. 9 would be made up of instructors in a large number of subjects, each assigning work to his students on the theory that his is the only subject. Take the teacher of English composition, for example, who meets his class two hours a week. Work enough to take up the student's entire time is suggested. Indeed if the course in composition occupies a term of sixteen weeks, the student must spend much of his time studying the theory of composition, examining the work of masters; and he must be constantly practicing, if he himself is to be able to write, which accomplishment ought to be the test of the product. How well must he be able to write? Standardize? Surely we shall be "going some" when school and college composition is standardized! But unfortunately this boy has other things to do in this same sixteen weeks. He must study chemistry, logic, a foreign language or two, mathematics, physics; must spend time in the gymnasium; attend the meetings of his fraternity; take part in the various college activities and have some social life at the same time. Think of the poor brain of that boy, the product on which No. 9, the various teachers, work. It just hardens to save itself—that's all. He is told at the end that he has an education. Nobody knows what an education is, as was stated before; so it is easy to say to a boy at the end of four years, "You are an educated man now." This to my mind is a crime. If scientific management can offer any reform, it will indeed be a happy day for the people among whom it is introduced.

Indeed it would seem that the only means of salvation lies in the introduction of scientific management. For each of the other functions, as marked out in Mr. Gilbreth's diagram,

would step in to help solve the problem. Here comes No. 8, Mr. Inspector, who is called in college, assistant professor. No, he would have to be more than that, for the assistant professor would control only one subject, say English, and in a college as large as the College of the City of New York, would have twenty men under him. So the difficulty grows, all the time, because the college of necessity must be divided into departments. The trouble is that the student has only one brain and only twenty-four hours in each day; and if he takes work in six departments, he is bound to be swamped under the present system. It would seem impracticable to assign him to only one department each semester. He would never get through at that rate. To return to Mr. Gilbreth's terms however: No. 9 must be considered the instructor in the department of,—say English; No. 8 the assistant professor in the English Department, who no doubt would be able to include functions No. 7, 6 and 5 (it being understood all the time, that the departments of music, drawing, physics, Latin, Greek, German, French, Spanish, Italian, mathematics, public speaking, physical instruction, mechanical arts, political science, philosophy, education, etc., etc., are equipped in the same way).

No. 4, the function of discipline as it appears in the factory, has to do only with Nos. 5, 6, 7, 8, 9, and not at all with the product. In college that function would be difficult, and still confined to each department, but complicated by the fact that it must include as well, the product or student body. For this reason it ought to include not only one but every department. No. 3 is usually performed by a special officer, called the curator or syndic, with a staff of clerks. This is one function which touches closely the business problem which I am not considering at all in this paper. The instruction card function 2 is included in the work of the professor. Here again is a great problem, because the instructions are given to the teacher by the professor in his department, without any real consideration for what the student has to do in the other departments, and must be so given if that subject is

to be adequately treated,—which it cannot be if the other subjects are given the treatment that they ought to receive. Function No. 1 is also looked after by the professor in each department. There is in almost every department a prescribed course. The student must take certain subjects in a certain order, and may elect other subjects in that department after a certain grade has been reached. The great problem here is not so much the routing in each department as the routing through the various departments.

This is the live question in the colleges to-day; and a long article might be written on the way it is failing of solution because each head of department feels that the importance of his subject demands all the time that has heretofore been assigned to it.

Coöperation, coördination, a proper balance in assignments,—and incidentally the student's rounded development,—would certainly be furthered by the introduction of scientific management.

APPENDIX.

THE PLACE OF MOTION STUDY IN SCIENTIFIC MANAGEMENT.*

I can best describe "The Place of Motion Study in Scientific Management" by first showing you two kinds of management. The first has been called traditional or military management, each man being responsible to one man above him and in charge of all below him. Traditional management is used in military and at times in religious and political organizations. The division is by men and by grades of men rather than by functions. The second plan of management is called functional or scientific management. Here the division is by functions, the first functional division being the separation of the planning from the performing. While each function is spoken of as being represented by one person, yet it may denote such a number of individuals as may be necessary.

The functions in the planning department are: (1) Route Clerk and Order of Work Clerk; (2) Instruction Card Clerk; (3) Time and Cost Clerk; (4) Disciplinarian. Those in the performing department are: (5) Gang Boss; (6) Speed Boss; (7) Repair Boss; (8) Inspector; (9) Individual Worker.

Each individual worker comes in touch with eight men or departments, not as a servant of eight masters, but as a student of eight teachers.

No. 1. The route clerk plans in advance the path of each piece of material as it passes through the shop. His function is not simply to look after the details of the moving, but to determine the entire transportation career of the material. Often the route clerk is able greatly to simplify the path of materials by rearrangement of machinery. I have had one case in my experience where in a woodworking shop it was

* An abstract of a paper by Mr. Frank B. Gilbreth, read before the University of Toronto Engineering Society, Friday, March 8, 1912.

cheaper to have the machinery placed on heavy pieces not fastened to the floor and to move it around to accommodate the peculiarities of sequence of events of each large order. The route clerk embodies his conclusions graphically in route sheets and charts, and they are worked out in detail by the instruction card department.

No. 2. The instruction card clerk must work out with the greatest detail instruction cards for each part of the work represented by the route sheets and charts, to show: first, the worker how to perform the particular work shown on the instruction card, and second, the foreman what he is to see that the worker does perform and just what he must teach the worker in order that he may perform his work to conform to the instruction card.

After the worker has performed his task, a return of the time his work took, together with the cost, is made to the time and cost clerk, No. 3, who figures out the payrolls, the bonuses and the cost of performing each task.

No. 4. The disciplinarian is the man who orders all matters pertaining to disciplining. He must be a broad gauge man and must be able to keep peace in the organization, to anticipate and prevent misunderstandings and to arbitrate fairly such disagreements as actually took place.

The fifth function or first in the performing department is that of a gang boss. The gang boss of to-day is not of the "strong arm" type of man, but one who can teach the worker methods shown on the instruction card. He must see that the worker performs the work in the exact manner and to the exact amount required. In order to get his best work, it is usually necessary to pay him a bonus for each man under him who in turn earns his bonus, and a double bonus if every man in the gang earns the bonus. It is readily seen how such a method should bring out coöperation which is essential to scientific management.

The speed boss, No. 6, sees that the machinery moves at exactly the right speed called for on the instruction card. The speed of a buzz planer or of a circular saw is dangerous

when too slow. The speed of a flywheel is dangerous when too fast. The most advantageous speed is called for on the instruction card, and the speed boss must be able to show the worker how this speed may be maintained.

The repair boss, No. 7, not only carries out repairs after breakdowns occur, but by periodic inspection and overhauling, prevents as far as possible such breakdowns.

No. 8. The inspector's work differs from that of the old type inspector in that it results in constructive rather than destructive criticism. The inspector under traditional management often comes around after the work has been done, condemns it and walks away. It is the duty of the inspector under scientific management to stand near the worker handling a new piece of work to see that he thoroughly understands it. In this way time, labor and material are saved.

As for the individual worker, No. 9, it will be seen that he receives not only an instruction card, telling him what he is to do, how he is to do it, how fast he is to do it, the quality of the work to be done and the bonus he will receive for doing it, but he receives personal teaching. The gang boss, the speed boss, the repair boss and the inspector are ready to help him when needed, and the functional foremen of the planning department are ready, at call, to explain their instructions.

Having shown the principal functions of scientific management and their relation to each other and to the individual worker, we are ready to concentrate on motion study.

The three most obvious economies to be obtained by motion study would be to use (1) the fewest motions, (2) the shortest motions and (3) the least fatiguing motions. These, however, are but a few of the savings that may be obtained. For example, a man should be given the work for which he is best adapted, not as in one case that came under my observation where the tallest of men performed a task that kept his hands almost constantly within six inches of the floor and where the smallest of men assisted in packing boxes in a pile about seven feet high.

Motion study is a part of function No. 2 of the planning

department and is an aid in making out the instruction card which must show how each operation may be done most economically. With motion study we class time study which is very intimately related to it. Motion study theoretically is supposed to furnish measurable units for time study, but the units are so small that they have not until recently been timeable. Now, however, ordinary photographs, stereoscopic photographs and motion picture photographs enable us to measure various motions with great accuracy. The results are quicker teaching, automaticity of motions and less fatigue. These all permit much faster motions.

There are a great many "variables that affect the motions" and I give here a partial list which will give a fair idea of what we mean by the term. The variables may be divided into three kinds, (1) the variables of the worker, (2) the variables of surroundings and equipment, (3) variables of the motion itself. Under (1) we have anatomy, contentment, creed, earning power, health, temperament, etc., under (2) appliances, clothes, entertainment, ventilation, lighting, quality and size of material used, special fatigue—eliminating devices, etc., under (3) acceleration, automaticity, combination with other motions, cost, effectiveness, foot-pounds of work accomplished, length, path, etc.

The scheme of motion study is to discover perfection and to perpetuate it automatically. After having determined the right motions, the right times for the motions, and having grouped them into cycles, we then determine the amount of rest that must be allowed to overcome fatigue. This will give us the standard task for the standard man who is the best man obtainable.

Now that we have so much literature on the subject of scientific management, why is it a fact that the progress has been so remarkably slow? The answer is that many people who are thoroughly familiar with the functions and duties of the men and of the various departments are not familiar with the pitfalls that are ever present. As has been said before, the entire scheme is dependent upon the hearty coöperation of

everybody in the organization, and workmen have been deceived so many times in the past that they are naturally suspicious and feel that scientific management must be smothered while it is still young. Again, it may be that the reason why the benefits of learning the right motions at first are not recognized is because the teachers do not know what the right motions are. On the other hand there has never been a case where scientific management has been put in properly that all the workmen did not realize that it was the best form of management for them.

Now that there have been many successful demonstrations of scientific management where workers receive much higher wages than ever before and where costs of production are lower than ever before, it seems unfortunate that the terrible wastes that are going on under traditional management should continue, and I hope that this university will consider seriously the study of scientific management, not only for the education of the young men who are going out in the world as engineers, but also with the idea of establishing a station for the collection of motion study and time study data, working in coöperation with similar colleges in the United States and Canada and also with various organizations who are doing good work towards investigating and disseminating information regarding scientific management, particularly the Society to Promote the Science of Management.

The problem is too great for any one firm, corporation, or college; in fact, this is work in which all English-speaking nations should unite as we have already done in our investigations of matters pertaining to medicine, agriculture, and the animal industries.

I hope to see an international bureau for the study, for the collection, study, cataloguing and dissemination of data relating to scientific management, that the workmen of all countries may be benefited and that unnecessary wastes may be eliminated.

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